Route to:

Return to:

INSTITUTE OF GAS TECHNOLOGY

THE GAS INDUSTRY'S OWN EDUCATIONAL AND RESEARCH FACILITY

CHICAGO 16, ILLINOIS

GAS ABSTRACTS

MARCH, 1961

VOLUME 17 NUMBER 3

AFFILIATED WITH

ILLINOIS INSTITUTE OF TECHNOLOGY

CONTENTS

1. **Management**—Gas industry progress, business problems, statistics, government regulation, safety, personnel, education..... 49

2. **Energy Supply and Economics**—Resources, reserves, and competitive applications of the fossil fuels and other sources of energy, including nuclear and solar energy..... 52

3. **Natural Gas and Petroleum Production**—Geology, exploration, drilling, well management, reservoir engineering..... 54

4. **Gas Conditioning and LPG Recovery**—Condensate, dust, CO_2 and sulfur removal, dehydration, odorization, oil fogging, humidification; LPG recovery and refining..... 56

5. **Natural Gas Transmission**—Pipelines, compressors, dispatching, flow regulation, communications, maintenance..... 57

6. **Gas and LPG Storage**—Holders, pressure tanks, underground storage; liquefaction, refrigerated storage..... 60

7. **Manufactured Gas and Chemical Processing**—Gasification of coal, oil; reformed gas; chemical treatment; byproducts; synthesis gas production and conversion; petrochemicals; catalysts, catalyst development..... 61

8. **Gas Distribution**—City utility systems: design, operation, maintenance; weather influence on peak loads and supply; LPG-air mixtures..... 63

9. **Gas Fuel Utilization and Appliances**—Domestic, commercial, industrial; burners; combustion research; air pollution..... 63

10. **Equipment and Instrumentation**—Production and handling equipment, and maintenance; computers; controls; measurement..... 66

11. **Materials of Construction, and Corrosion**—Metals, refractories, plastics; corrosion measurement, prevention..... 67

12. **Analytical Methods and Tests**—Standard and research techniques for gas-making materials, products, processes; instrumental analysis..... 68

13. **Basic Science**—Chemistry, physics and basic engineering related to gas technology; physical properties of gases: phase equilibria, thermodynamics, reaction kinetics, heat and mass transfer, fluid flow..... 70

Services Available to Readers—Photocopies, microfilm, Russian translations, bibliographies and literature searches, *Gas Abstracts on Cards*, back numbers of *Gas Abstracts*.....**Inside Back Cover**

Publications Abstracted for Gas Abstracts.....**Back Cover**

O. P. BRYSCH, Editor

P. J. CHATTA, Assistant Editor

GAS ABSTRACTS is published and distributed monthly by the Institute of Gas Technology, Chicago 16, Illinois. The contents of selected papers and patents are reviewed impartially by the editorial staff and material of potential interest to the Gas Industry is presented.

Subscription rates to nonmembers of the Institute: $18.00 per year to U. S. addresses; $22.00 foreign. Regardless of the month in which it is entered, each subscription starts with the January issue. A gold-stamped fabrikoid binder for the year, and title- and end-pages for that volume, are sent with the January issue. A complete index to the year's issues is mailed as soon after the year's end as it can be prepared, edited and printed.

Copyright 1961 by the Institute of Gas Technology. Printed in the U.S.A.

A microfilm edition of Gas Abstracts can be supplied by University Microfilms, 313 N. First St., Ann Arbor, Michigan.

1. MANAGEMENT

Gas Industry Expansion

Enchilada Inch Hearings Held. J. F. Ebdon. *Gas 37,* 150 (1961) Mar. (5 pp.)

Author reports on first three days of hearings on the Enchilada Inch (see *Gas Abstracts 17,* 4). Hearings involve the California Gas Transmission Co. (a TGT subsidiary) and its quest for a certificate of public convenience and necessity to build that part of the Texas-Mexico-California pipeline—known to all except the Applicants and Protestants as the Enchilada Inch—which it proposes to install between the California-Mexico international boundary and assorted Southern California Edison Co. kilowatt-creators in the Los Angeles basin. Issues and evidence presented during these first hearings are summarized.

Gas Industry Management

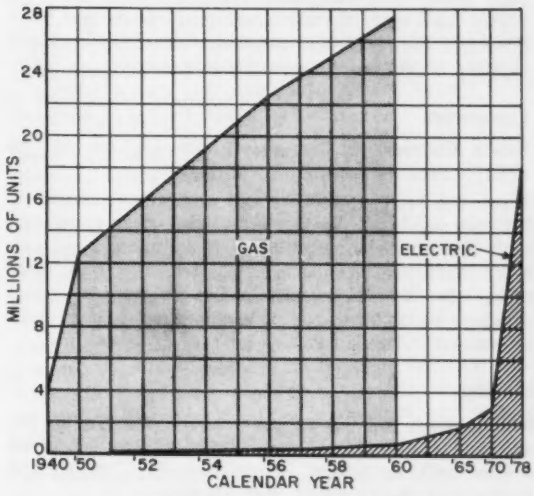
Introducing Supply and Demand Control for Gas Producer Regulation. A. K. Lee. *Public Util. Fortnightly 67,* 369 (1961) Mar. 16 (7 pp.)

Congress can, in author's opinion, make a single change in the Natural Gas Act that will eliminate the shifting of gas pipeline costs from industrial, inferior, or dump users to residential or firm users through the present two-part rate arrangement. His proposal: by law or commission action provide that no natural gas shall be sold by any interstate pipeline at less than the average cost of the highest priced one-third of gas purchased by it during the preceding year plus one-half the average transportation charge for firm gas transported during that year. The transportation charge for firm gas shall equal, with zoning variations, the difference between the projected gas costs for the ensuing year and the amount necessary after payment of all approved expenses to create a fair and reasonable return.

Municipal Gas Plant Sells Out. R. C. Hayes. *Public Util. Fortnightly 67,* 289 (1961) Mar. 2 (8 pp.)

When a municipally owned gas utility in a progressive city of 11,000 persons faces bankruptcy after only three years of operation and is replaced at the city's request by an investor-owned gas company, that is news. In Moses Lake, Washington, the city-owned natural gas distribution system, whose bond and engineering promoters had confidently forecast a prosperous future, was deep in financial mire even before the end of its third year. It had spent $1.2 million of municipal bonds, for which it had received but $711,000 of distribution system; it had 39 miles of mains and 1000 service connections, but only 400 customers; and, finally, its first out-of-revenue interest payment was coming due and there were insufficient funds to meet it. Analysis of the circumstances leading to the failure of Moses Lake's gas venture suggests weaknesses that may be found in other municipal gas utilities, or in propositions to establish new ones. Situation has its parallels in many other parts of the country.

Growth of Gas and Electric Heat



(Adapted from *The Truth About Electric Heat.* See abstract, p. 53)

Tightening of Controls in First Stages. N. Regeimbal. *Gas 37,* 17 (1961) Mar. (2 pp.)

Tightening government controls over the natural gas industry is in the first stages. Courts, Congress, and the White House are designing this pattern. The new administration will not waste much time seeking: a reduction of present 27½ percent gas and oil depletion allowances; a national fuels policy with end use controls over regulatory agencies such as the FPC. Sources inside the government freely admit these plans.

Appliances

Gas Heating: 1960. Industry's Second-Best Year. *Gas Heat and Comfort Cooling 12,* 25 (1961) Mar. (8 pp.)

As 1960 ended, the industry had sold 1,189,520 pieces of central gas heating equipment against 1,320,440 in 1959. Dealers also reported the sale of 2,635,250 automatic water heaters, 1,207,840 space heaters, 391,720 wall furnaces, 137,870 direct gas-fired unit heaters, and 87,450 floor furnaces. In all classes of equipment these volumes are below the 1959 levels. Gas central heating in operation at the end of the year had increased 8.7 percent to 12,941,600 units. This comprises 8,633,300 gas furnaces, 1,235,000 gas boilers, and 3,073,300 conversion burners. Of the total automatic heating sales in 1960, gas-fired equipment accounted for 65.1 percent, up from 64.0 percent in 1959.

Gas Gains a Growing Share of a Rapidly Growing Market. R. Clay. *Butane-Propane News 23,* 52 (1961) Mar. (2 pp.)

Gas industries' share of the clothes dryer market has grown exactly 12.5 percent in the last eight years. The low point was 22.79 percent of the market in 1953, 168,000 out of a total of 737,000 dryers. The low point, unit-wise, was 1951, when there were

138,000 gas dryers out of a total of 492,000. The high point, unit-wise, was 1959, when 486,000 gas dryers were sold. On a percentage-of-the-market basis, however, last year was the best with 35.29 percent, capping eight straight years of increases.

Cryogenics

How's Business in Cryogenics? *Chem. Eng. 68,* 94 (1961) Feb. 20 (4 pp.)

Much has been published about cryogenics technology, but not much on the question: what does cryogenics look like—present and future—as a business proposition? Recorded in article are interviews with three men, who hold key posts in Linde's new cryogenic products department, and whose business it is to have the answer. Article includes table of cryogenic use.

Drilling

Drilling Costs Still Going Up Onshore. *Oil Gas J. 59,* 81 (1961) Mar. 13 (3 pp.); **Deep Drilling Decreased 6% in 1960.** E. Adams. *Petrol. Eng. 33* (Drilling and Producing), B-19 (1961) Mar. (5 pp.)

Better technology has cut expenses offshore and at depths below 15,000 feet. But cost of drilling the average U. S. well has spiraled $3300 in three years. One reason: costs of gaswells are almost twice as much as oilwells.

Drop in U. S. Drilling in 1961 Forecast. *World Oil 152,* 69 (1961) Feb. 15 (2 pp.)

World Oil's annual drilling survey, based on detailed analyses of oil company drilling programs, forecasts the drilling of 46,079 new wells and 191.3 million feet of hole in the United States during the current year. This would reflect a slight downturn of 699 wells, or 1.5 percent, from the 46,778 wells completed in 1960, and 3.2 million feet of hole, or 1.7 percent less than the 194.5 million feet drilling in 1960.

Foreign Activities

Current Developments in the French Gas Industry. R. Odier. *Gas J. 305,* 233 (1961) Feb. 15 (7 pp.); *Gas World 153,* 281 (1961) Feb. 18 (3 pp.)

At the end of 1960, there were 591 private gas undertakings in France, distributing mostly coal gas, and about the same number of local distribution systems. But there had been a huge development of bulk transportation lines and a considerable number of gasworks had been closed down. They had been replaced by propane or propane-air stations, or by cracking plants using petroleum products as feedstock. Author predicts that in about two years' time, probably the only coal being carbonized will be in the coke oven plants located near Paris, Rouen and Strasburg; all other distribution systems will have been linked to a transportation line of coke oven or natural gas, or converted to use of liquid or gaseous hydrocarbons as feedstock.

Fuels for Argentina. J. T. Cannan. (New York: ASME Paper No. 60-PET-40; 8 pp. $1.00/copy; $0.50 to members.)

The Campo Duran Pipelines of Argentina are outstanding examples of sound engineering practice combined with practical economics to add productive capacity and new industry to a resources-rich area, say authors. Time-proven U. S. design incorporated materials and equipment from European manufacturers for ultimate assembly by relatively inexperienced operators under remote and difficult conditions. The logistic problem of supplying the right equipment at the proper time and place from many parts of the world far exceeded the difficulty of design. American experience and design have been important factors in the successful completion of the 1100-mile, 22- and 24-inch natural gas line and the 900-mile products line which will bring critically needed fuels from northern Argentina to the industrial and population center of Buenos Aires.

1960 Was a Big Year for Pakistan Oil and Gas Industry. *Progress 5,* 1 (1961) Jan. (3 pp.)

Summary of achievements enjoyed by Pakistan's oil and gas industry during 1960 is presented. Total Sui gas purification capacity was doubled from 74 to 148 MMCF/day to meet the increasing demands for gas. Sylhet gasfield, discovered by Pakistan Petroleum Ltd. (PPL) in 1955, was connected by a 27-mile pipeline to the Fenchuganj power plant. To develop existing oil- and gasfields, four wells were drilled. PPL drilled Sui well No. 7 to a depth of 4450 feet. It is by far the best gas producer in the field to date.

Real Canadian Gas Boom Lies Ahead. *Oil Gas J. 59,* 102 (1961) Mar. 13.

Fourfold increase in sales of Canadian natural gas is expected during the decade. This would boost sales from the 1960 level of 420 billion CF to 1.7 trillion CF in 1970. On a daily basis this would be an increase from 1.2 to 4.7 billion CF, the crude oil equivalent of almost 750,000 bbl/day. Exports are due to increase from one-sixth of the total in 1960 to half of all the sales in 1970. Revenues from exports will increase from $17 million in 1959 to $100 million in 1962 and an estimated $300 million in 1970.

The Soviet Oil and Gas Industry. D. B. Shimkin. *Oil and Gas Compact Bull. 19,* 12 (1960) Dec. (11 pp.)

Ten years ago, the Soviet Union had barely recovered from the effects of World War II, and was a net importer of petroleum and its products. By 1955, Soviet net exports of crude oil and refined products had risen to 3.6 million metric tons, or about 26 million barrels. This year they aggregated 27.5 million metric tons, or almost 200 million barrels. Today, the Soviet Union is aggressively seeking new foreign outlets for its crude oil and refined products. It is now supplying Cuba, and has contracted to ship a million tons of products annually for three years to India. There were no Soviet exports of oil to either country in 1959. Moreover, Soviet efforts to expand existing markets are also intense. In November, 1960, the Italian government reportedly contracted to buy some 19 million metric tons of Soviet crude, over a five-year period, in addition to

current Italian imports, which are coming to about 4.7 million metric tons for 1960. Characteristically, such transactions comprise portions of longer-terms bilateral agreements, utilizing soft currencies or barter, and charge nominally very cheap prices for Soviet goods.

Helium

Four Corners Keeps Lead in Production of Helium Gas. J. W. Dean and R. E. Lauth. *Oil Gas J. 59,* 194 (1961) Feb. 20 (6 pp.)

Existence of significant accumulations of this rare gas has been known in the Four Corners region for several decades. Some of the more commonly known reservoirs, Rattlesnake and Hogback fields of New Mexico, Model dome of Colorado, Harley dome of Utah, and Pinta dome of Arizona, have particularly rich contents of this inert gas. Pinta dome, in northeastern Arizona, is the richest. It has a helium content ranging between 8-9 percent. Arizona reservoirs, with 8-10 percent helium content are the richest known in the free world.

Federal Power Commission

The Folklore of Regulation. E. C. McKeage. *Public Util. Fortnightly 67,* 361 (1961) Mar. 16 (8 pp.)

Author, who has had experience in both the judicial and regulatory fields, presents his critique of the much-publicized Landis report. In essence, he agrees with the spirit of the report, but advocates that federal regulatory agencies should not be placed under the scrutiny or monitorship of a representative of the executive branch of the federal government, as Dean Landis proposes. Instead, author believes that what is needed is a Regulatory Conference, similar to the Judicial Conference in the judicial field of the federal government and in other jurisdictions.

The Landis Report: Boon or Bane? C. F. Phillips, Jr. *Public Util. Fortnightly 67,* 217 (1961) Feb. 16 (8 pp.)

Critics call the report disappointing (see *Gas Abstracts 17,* 26). The analysis of regulatory agency faults is deemed incisive, but recommendations for rectifying them weak and ineffectual. Objectionable is the idea of tampering with the agencies' independence through presidential control by way of a czar. Less, not more, bureaucracy and political interference must be enjoyed to improve regulation, author believes.

Incinerators

Gas Helps City Clean Up Its Air. M. Sterling. *A.G.A. Monthly 43,* 21 (1961) Feb. (4 pp.)

Article describes cooperative efforts of Detroit's local gas utility, a subcommittee of the Gas Appliance Manufacturers Association and the Detroit Bureau of Air Pollution Control in developing new gas incinerator standards.

Petrochemicals

The Italian Petrochemical Industry. B. Orsoni and M. Ottolenghi. *Chem. Eng. Progress 57,* 43 (1961) Feb. (5 pp.)

At present, Italy is the fourth largest chemical producer in Western Europe and is well prepared to meet increasing competition from the gradual implementation of the European Common Market. In 1958 and 1959, capacity was considerably expanded, particularly in petrochemicals, and new plants as well as new units in existing facilities began operation.

Japan's Petrochemical Industry. A. M. Griswold and S. Ishihara. *Chem. Eng. Progress 57,* 54 (1961) Feb. (6 pp.)

Based on 1955 to 1959 inclusive data, the Japanese economy advanced at an average annual rate of 11.3 percent. The chemical industry showed a growth rate of 14.2 percent which was less than that shown by five other industries: machine, petroleum and coal products, rubber, iron and steel, and the nonferrous metals industry. However, within the chemical industry, synthetic resins and plastics showed a growth rate of 29.8 percent, and synthetic organics grew at an average annual rate of 26.1 percent during the period.

Petrochemicals in Britain. H. P. Hodge. *Chem. Eng. Progress 57,* 37 (1961) Feb. (7 pp.)

Organic chemical industry in the United Kingdom, together with the industries converting organic chemicals into end products such as plastics, synthetic rubber, detergents, etc., shows the most dynamic growth rates of any major manufacturing industry in Britain. From 1949 to 1959, the output of organic chemicals has increased 280 percent—a growth of 11 percent/yr. During this period the average growth rate for all chemicals in the United Kingdom was 7 percent/yr, as against 15 percent for plastics and 37 percent for chemicals from petroleum. This is compared with average annual growth rates of 6 percent for the production of motor vehicles and a little over 3 percent for all manufacturing industries.

Petrochemicals in France. F. A. Escherich. *Chem. Eng. Progress 57,* 48 (1961) Feb. (6 pp.)

French chemical industry is geographically scattered. There are seven main areas, most important of which is the Lacq area. In 1958 plans were made and construction started to remove the high H_2S concentration in natural gas at Lacq and to produce sulfur. Once all the purification facilities are completed, France, by 1962-63, will be producing 1.2-1.3 million tons of elemental sulfur. Principal factor causing the rapid rise in the chemical production index of France has been the tremendous increase in plastics, synthetic fibers, and synthetic rubber production.

Why Not a More Intelligent Use of Commercial Propane? G. F. Wright. *Can. Gas J. 54,* 26 (1961) Jan. (2 pp.)

In view of the important uses one may well ask why Canadian refiners are down-grading propylene by burning it as a contaminant of commercial propane. The answer will be given that there is insufficient market in Canada for economical unit conversion to the several desirable chemicals. In view of the present importance of polypropylene, this argument may be specious. But also apathy, the trait of government and business too close to the United States, plays a large part.

Pipeline Construction

Big New LPG Line in Midwest Planned. *Oil Gas J. 59,* 90 (1961) Mar. 13.

Northern Gas Products Co., a wholly owned subsidiary of Northern Natural Gas Co., and Great Lakes Pipe Line Co. will operate an 800-mile LPG pipeline system from central Kansas to the St. Paul-Minneapolis and central Illinois areas. NGP will build a 350-mile 8-inch pipeline from its new extraction plant at Bushton, Kans., to Des Moines, Iowa, where it will connect with Great Lakes. Great Lakes, in turn, will convert two 6-inch pipelines, now used for products, to handle LPG. One line extends north from Des Moines about 200 miles to the Twin Cities area; the other almost directly east, about 250 miles, to the Chicago area. The system will have a capacity of 40,000 bbl/day.

California Becoming Nation's No. 1 Gas Market. J. P. O'Donnell. *Oil Gas J. 59,* 122 (1961) Mar. 13 (6 pp.)

Until less than one year ago, California had a single out-of-state supplier, El Paso Natural Gas Co. Because of its monopoly for a dozen years, El Paso grew 50 times. Now California not only has a second supplier, Transwestern Pipeline Co., but is awaiting completion of the Alberta-San Francisco line, will further benefit from the FPC-approved El Paso-Colorado line, and may eventually be served by the Enchilada Inch (see page 49). Another entry is International Gas Co. which has been working for a number of years to deliver Mexican gas to California. These projects, building and proposed, will double present supply. They represent a $2.5-billion investment in 13,700 miles to deliver 3.9 billion CF/day.

Special Report on Alberta-California Gas Pipeline System. P. Reed. *Oil Gas J. 59,* 109 (1961) Mar. 13 (13 pp.); **Design Details of Alberta-California Line Unfolding.** F. H. Love. *Pipeline Eng. 33,* 34a (1961) Mar. (4 pp.)

Author covers the design of the line and its stations, underground storage, reserves, markets and costs. Field plants facilitated construction considerably. Because Canadian gas is not cheap, it has been essential to provide economical transportation utilizing the advantages of the large-diameter 36-inch pipe so that Canadian gas would be competitive from the start with gas from other sources. Arrangements for acquiring gas and transmitting it have been made on an unusual cost-of-service basis. The system has been designed for ultimate export of 1173 MMCF/day; ultimate delivery to California will be 800 MMCF/day. El Paso Natural Gas Co. and Canadian Montana Pipe Line Co. will purchase the rest—303 and 36 MMCF/day, respectively.

Process Design

To Operating Companies: A Checklist for Project Engineers. M. R. Noack. *Petrol. Refiner 40,* 105 (1961) Feb. (7 pp.)

Project engineer's checklist has been developed from the viewpoint of the operating company that is about to go into a building contract. Covering every step from the beginning file system to the final contract, this guide will ensure that every important detail has been investigated before the contract is signed. It is especially adapted to the definitive estimates.

Water

The Hydrate Process. W. G. Knox, M. Hess, G. E. Jones, Jr., and H. B. Smith, Jr. *Chem. Eng. Progress 57,* 66 (1961) Feb. (6 pp.)

This is the first formal presentation of the hydrate process and covers engineering development to date. The initial effort was aimed at the selection of the most commercially feasible hydrate-forming material from among those covered in Koppers' patent. Basically, the propane hydrate process consists of combining propane and water to form insoluble clathrate crystals having an approximate composition of 17 moles of water for every mole of propane. The crystals are separated from the mother liquor, washed, and then decomposed to form immiscible layers of salt-free water and propane.

2. ENERGY SUPPLY AND ECONOMICS

Natural Gas

Expanding Horizons. W. T. K. Braunholtz. *Gas J. 305,* 206 (1961) Feb. 8 (3 pp.)

Article comprises excerpts of a paper by the author in which he discussed the phenomenal expansions in gas consumption in certain countries that have been fortunate enough to tap vast underground supplies of natural gas. His comments on the United States, Canada, France and the USSR are included.

Continued Expansion Seen in Outlook for Natural Gas Processing. C. E. Webber. *Petro/Chem Eng. 33,* C-14 (1961) Mar. (3 pp.)

Since the U.S. Supreme Court handed down the Phillips decision in 1954, the growth of natural gas production has dropped. Uncertainties and lack of incentive for exploration and production activities created by federal regulation of producers are taking their toll. Still, the long-term outlook for expansion is good, even though the rate will be at a lesser pace, says author.

Natural Gas Is Texas' Industrial Lifeblood. F. J. Gardner. *Oil Gas J. 59,* 167 (1961) Mar. 13 (5 pp.)

Natural gas has replaced crude oil as the fair-haired child of Texas' army of oil operators—and a large amount of money is being spent to find it. The state holds nearly half (44.8 per cent) of all the natural gas reserves in the United States and is therefore the biggest source of production. Latest estimates say that Texas has 122.5 trillion CF; at the end of World War II, this figure was only 86.4 trillion CF. At the same time, Texas is its own best customer, for half of its production is consumed in the state itself.

Recent Developments in Field Gas-Handling Facilities. W. D. Clift, R. R. Die and H. R. Galloway. (New York: ASME Paper No. 60-PET-36; 8 pp. $1.00/copy; $0.50 to members.)

Phenomenal growth of the natural gas industry during the past 15 years has provided the impetus for the many significant developments that have been made in field gas handling facilities. Natural gas and gas liquids now supply about 30 percent of the nation's energy requirements, and it is interesting to note that the energy content of proved gas reserves exceeds that of crude oil reserves. Consequently, the petroleum industry is acutely aware of the fact that natural gas is a valuable commodity, and production and sales engineers have discovered that they now need to know more about the processes and equipment used in the field to separate, compress, dehydrate and process natural gas. New equipment and improvements to existing equipment are continuously being made. Both the producer and equipment manufacturer must keep abreast of these developments if they are to survive in their competitive industries.

Electricity

Ten Ways We Fail to Meet Electric Competition. Part 4. Our Electric Competition's Handicaps. C. C. Turner. *LP-Gas 21,* 17 (1961) Mar. (3 pp.)

Author compares tangible and intangible assets of gas to electricity, with special emphasis on the thermal electric unit and the fuel cell. In the area of appliances, author claims that gas can do the job faster and more economically. The intangible assets include dependability and the fact that it is to the public's advantage that the gas industry is not a protected monopoly.

The Truth About Electric Heat. W. W. Clark. *Butane-Propane News 23,* 29 (1961) Mar. (12 pp.)

Although experts within the electric industry cannot agree statistically, observers both within and without the industry are sure of one thing—electric utilities are making great progress in this thing called "total electric living." One source predicts that by 1970 there will be 3 million electrically heated homes—and the industry has already started toward this goal by allocating some $20 million for promotion in 1960. Author discusses alledged advantages of electric heat and real advantages of gas, and points out steps that can be taken by the gas industry to meet this competition head-on.

Energy Sources

New Spark in Power Units. *Chem. Week 88,* 92 (1961) Feb. 25 (5 pp.)

Brief resume of novel power systems is given, including main U. S. investigators, typical materials and status. Systems discussed: solar and fuel cells; thermoelectric converter; thermionic generator; and magnetohydrodynamic generator.

Fuel Cells

Electrical Conductance Cell Assembly for Precise Measurements with Carbonates, Oxides, and Fluorides up to 1000°C. G. J. Janz and M. R. Lorena. *Rev. Sci. Instruments 32,* 130 (1961) Feb. (4 pp.)

Conductance cell assembly is described of capillary design with a cell constant sufficiently high to permit precise electrical conductance measurements with the standard-type precision conductance bridge circuits. Important features are the use of single crystal grade MgO for construction of the capillaries that determine the resistance for the electrolyte in the conductance cell, and the use of such materials as gold, or gold-palladium alloy to construct the various other components of the cell that contact the molten salts.

Fuel Cell Progress. The Last Year and the Future. A. D. S. Tantram. *Fuel Efficiency 9,* 50 (1961) Feb. (2 pp.)

Author reviews rapidly rising interest now being shown in fuel cells both in Great Britain and in the United States. Figures of the order of $20-$30 million have been spoken of as the present investment committed to fuel cell development in the latter country over the next few years. Most of this money comes from private firms and not the government. No comparable monetary commitments have as yet been made in Great Britain.

Seagoing Fuel-Cell Power at Prototype Design Stage. *Ind. Sci. and Eng. 8,* 26 (1961) Jan. (2 pp.)

One of the first major applications of the fuel cell principle to specific power and service requirements is represented in a $764,000 contract awarded by the Navy Bureau of Ships to the M. W. Kellogg Co. Based on the success of two earlier research programs by the firm, the new development project calls for the design and testing of a complete chemical power plant, a prototype of a Naval version for use by that service.

LPG

Western Canada's Demand Forecast Indicates Continued LP Surplus. F. L. Thompson. *Can. Gas J. 54,* 21 (1961) Jan. (3 pp.)

It is generally agreed that there will be a problem in marketing the surplus volumes of LPG. Although occasionally a close balance appears on paper between production and market demand, it must be recognized that the production is constant whereas the domestic market is a two to one ratio winter and summer and in addition, the storage facilities are not adequate to accommodate the ratio. In general the Chicago area was considered the most desirable market for surplus products —best in revenue and the only market that could accommodate the estimated surpluses. The estimates of volumes surplus to the Alberta market demand include 7000/10,000 bbl/c. day of propane, 10,000/15,000 bbl/c. day of butane and 50,000/60,000 bbl/c. day of condensate.

Magnetohydrodynamics

Recent Advances in Electric Arc Plasma Generation Technology. R. R. John and W. L. Bade. *ARS J. 31,* 4 (1961) Jan. (14 pp.)

During the next few years, plasma generators will receive increasingly widespread use in high enthalpy simulation, space propulsion and other fields, say authors. These applications will generate increasingly severe performance requirements which will substantially exceed the capabilities of all existing types of arc

gas heating equipment. The primary requirements will be for operation at high pressure ($\cong$ 100 atm) and enthalpy (300 to 900 RT_o), with very low contamination of the heated gas stream and with long electrode life. Empirical trends observed in performance data for existing units indicate that achievement of these goals will necessitate major advances; ultimate limitations on plasma generator performance have not been established.

Petroleum

Oil Can't Relax in Its Maturity. M. E. Hubbard. *Oil Gas J. 59,* 138 (1961) Feb. 20 (4 pp.)

Instead of relaxing, oil must gird for a continuing competitive struggle with other forms of energy. If it competes too aggressively, it will invite protective restriction. One thing is sure, however: the need for energy will continue to grow, though at a slower rate than has prevailed during the postwar years. One-half of the future growth in Europe's energy requirements will be met by increased oil imports. Over the next 15 years, these can be expected to grow by 10-11 million tons annually, on the average.

Shale Oil

Hot Water Process for the Extraction of Oil from Bituminous Sands and Like Oil Bearing Material. G. R. Coulson (assigned to Can-Amera Oil Sands Development Ltd.) U. S. 2,968,603 (1961) Jan. 17.

Process is claimed for extraction of oil from bituminous or tar sands which comprises the known step of pulping the raw sand with hot water and passing the slurry to a settling tank or thickener. The improvement consists in diluting the foam or overflow from the settler with a light hydrocarbon oil (kerosine) and centrifuging, while maintaining the water in a thick middle layer to separate the solids and oil. The water layer from the settler is also centrifuged to clarify it for reuse.

Recovery of Oil from Oil Shale. H. O. Woodruff (assigned to Texaco, Inc.) U.S. 2,970,826 (1961) Feb. 7.

Process is claimed for the extraction of shale oil from subterranean strata. Horizontal passages are formed in the stratum from an outcrop, one along the upper and another parallel along the lower portion. These passages are driven to intersect a vertical well at some distance. Air is blown through one passage and combustion is initiated there. Oil is distilled toward the well, where it is extracted and combustion gases returned through the other horizontal passage.

Solar Energy

Solar Energy Collectors. A. B. Newton (assigned to Coleman Co., Inc.) U. S. 2,969,788 (1961) Jan. 31.

High-temperature solar energy collector is claimed which comprises a plurality of tubes manifold-connected across the bottom of a glass-topped insulated chamber. Each tube is provided with a pair of parallel polished-sheet reflectors, with convex surfaces, which are pivoted at lower edge and separated to form a V-shaped slot. The top edges of all the reflectors are linked by pins into short slots in bars which run lengthwise of the chamber. Bar end-screw adjustments permit adjustment of the reflectors to focus the solar radiation upon the tubes throughout the day.

System for Converting Solar Energy into Mechanical Energy. R. J. Rowekamp. U. S. 2,969,637 (1961) Jan. 31.

System for collecting and converting solar energy is claimed, in which solar radiation acts upon a multiple-pipe boiler containing a volatile liquid such as dichlorodifluoromethane. This boiler forms the solar exposed (heated) surface of the system. The expanded vapor drives a turbine-generator system and is compressed and passed to a water condenser from which it is stored in a recycling reservoir. Water heated in the condenser can be circulated to the boiler system for short periods of operation.

Thermoelectricity

Gas-Fired Wall Heater Generates Its Own Electricity. R. W. Fritts. *LP-Gas 21,* 20 (1961) Mar. (4 pp.)

Thermoelectricity is not new to the gas industry; since the 1930's miniature metallic thermocouples heated by small pilot burners have generated millions of kilowatt hours to operate automatic shut-off valves on all kinds of gas equipment. Continuing research has produced higher conversion efficiencies. Formerly, all forced air and hot water gas heating systems have required electric connections for the operation of blowers and pumps. With the new thermoelectric materials available now in commercial quantities, the entire electric power requirements for operation of gas heating equipment can be supplied directly from a thermoelectric generator mounted on the combustion chamber.

3. NATURAL GAS AND PETROLEUM PRODUCTION

Drilling

How to Use Foaming Agents in Air and Gas Drilling. W. C. Goins, Jr. and H. J. Magner. *World Oil 152,* 59 (1961) Mar. (6 pp.)

Use of foam-producing agents to remove cuttings and water at operable pressures has done much to extend the use of air drilling to wells with water flows of up to 200 bbl/hr. Author presents informative report on the chemicals, equipment and techniques used, plus associated problems and potentials of foaming agents.

Foam Agents and Foam Drilling. A. S. Murray and J. E. Eckel. *Oil Gas J. 59,* 125 (1961) Feb. 20 (5 pp.)

Foam drilling can handle larger flows of formation water than is generally realized. Successful foam drilling needs constant presence of skilled drilling personnel to collect and evaluate data so that techniques can be improved on successive jobs. Foam drilling, like mud

drilling, requires careful evaluation of fluid-flow properties and the injection of precise amounts of additives at controlled rates. Air-drilling-technology schools are needed, say authors. There is need for a standard test for screening all foaming agents on a common basis. Research studies should be conducted to find out more about the lifting-capacity requirements and flow characteristics of a two-phase flow system under borehole conditions.

What's New in the Drilling Industry. J. F. Earl. *World Oil 152,* 63 (1961) Feb. 15 (6 pp.)

Although no radical changes occurred last year in drilling technology, several new types of equipment and improved practices emerged which are helping drilling contractors compete in an industry besieged by mounting costs. Some of the more important improvements that resulted from extensive research, engineering, and practical field application of current drilling equipment and techniques include: circulating medium, new rig designs, new tools and equipment, and improved drilling practices.

Drilling Muds

Chromates Stabilize Shale Control Muds at High Temperatures. W. J. Weiss, J. S. Brukner and C. O. Walker. *Petrol. Eng. 33* (Drilling and Producing), B-35 (1961) Mar. (6 pp.)

Anionic chromium compounds such as sodium chromate and sodium dichromate make shale control muds less sensitive to high temperatures. Additives have proven successful to 350°F.

Drilling Fluids: A Current Review. Part 3. The Mud Programme. G. K. Jones. *Petrol. 24,* 53 (1961) Feb. (4 pp.)

General principles governing the formulation and use of oilwell drilling fluids were outlined in previous articles (see *Gas Abstracts 16,* 54). Some indication was given of the wide variety of drilling fluids that are at the disposal of the petroleum engineer, and their use in overcoming specific hazards. The criteria that determine the choice of drilling fluid, and thus the mud program, together with some further details of drilling fluid practice, are discussed in this concluding article.

Exploration

F Sands: Sacramento Valley Gas Target. *Petrol. Week 12,* 19 (1961) Mar. 3 (2 pp.)

Year 1960 was the biggest to date: 240 wells were drilled, redrilled, or deepened—an increase of 39 percent in total wells drilled and 61 percent in total footage drilled when compared with 1959, the previous best year for the state. Exploratory holes numbered 146, and accounted for over 40 percent of the total wildcats and wildcat footage drilled in California. These exploratory tests accounted for 11 new fields, 11 new pools, and 5 extensions, for an overall success ratio of 1 to 5.4.

Logging

Techniques of Electric Log Interpretation. E. R. Atkins, Jr. *J. Petrol. Tech. 13,* 118 (1961) Feb. (7 pp.)

Generally used techniques of electric log interpretation are reviewed and discussed, including the determination of 1) formation water resistivity from the SP curve; 2) true resistivity values from log data; 3) water saturation from electric logs; and 4) formation porosity from resistivity data. Particular emphasis is placed on the assumptions made in log interpretation.

Offshore Operations

Optimism Is the Keynote as Offshore Activity Pushes Steadily Upward. *Petrol. Week 12,* 36 (1961) Feb. 17 (14 pp.)

All signs indicate a real expansion in offshore activity this year, with the focus again on submerged lands off Louisiana. This vast oil province, fulfilling its earlier promise of stabilization, has entered 1961 looking very good, compared with many other domestic areas. Construction yards reflect the tempo, and designers are busy on units for deeper waters.

Pipe Stresses When Drilling from a Floating Vessel. E. R. Lind. (New York: ASME Paper No. 60-PET-49; 15 pp. $1.00/copy; $0.50 to members.)

When drilling from a floating vessel, the bending stresses due to the roll of the ship, displacement of the ship from over the hole, and ocean current drag force must be added to the usual drilling stresses. Formulas are presented to permit calculation of these stresses. As the hole depth increases, the roll and/or displacement limits must be decreased to prevent overstressing the pipe. Study reported is concerned with deep holes; that is, the depth of the hole is more than ten times the depth of the water. Forumlas are presented for shallow holes in deep water, but are only discussed briefly.

Reservoir Engineering

Radioactive Inert Gases as Tracers for Petroleum Reservoir Studies. F. E. Armstrong, W. D. Howell, and J. W. Watkins. *U. S. Bur. Mines Rep. Invest. 5733.* (Washington, D. C.: U. S. Dept. of the Interior 1961, 15 pp.)

Report describes development and application by the Bureau of Mines of techniques and instruments for using radioactive inert-gas tracers to determine flow paths through petroleum reservoirs that have natural fracture systems and for which water injection has been selected as the stimulative production method. A field test was conducted to prove the techniques and evaluate instrumentation. The feasibility of applying the techniques and instruments to the solution of reservoir problems in other stimulative methods of production also is discussed.

Well Practice

Advancements in Production Methods—1960. R. W. Scott. *World Oil 152,* 74 (1961) Feb. 15 (7 pp.)

Many new production techniques and tools were introduced during 1960. As in previous years, chief interest was devoted to reducing costs and increasing operational efficiency. Article reviews several of the major oil

industry's 1960 achievements in production, highlighted by completion of the first sextuple well by Sunray Mid-Continental Oil Company. Three strings of 2⅞-inch casing were run in a single hole and equipped with 1½-inch tubing strings and packers, thus providing three "old style" dual producing wells. The same operator recently ran four 2⅞-inch casing strings in a single hole.

A Sonic Method for Analyzing the Quality of Cementation of Borehole Casings. M. Grosmangin, F. P. Kokesh and P. Majani. *J. Petrol. Tech. 13,* 165 (1961) Feb. (7 pp.)

Logging method described in this paper operates on the principle that the attenuation of a sonic pulse transmitted by a casing is greatly increased when that casing is bonded to an outer annulus of hard material (such as set cement) which has an appreciably smaller sonic-wave velocity than that of the casing. Laboratory studies have shown straight-forward relationships between attentuation and such variables as source-detector spacing and percent of circumference bonded. It is shown that cement not set or not bonded to the casing has comparatively little attenuating effect. Field examples show not only the cement top, but also the variation in cementation quality below the top. Further, the increase of bonding with time and after squeeze cementation is depicted. The detection of poor cement jobs is confirmed by production tests and by formation-test results.

Automatic Gas Well Dewatering System Cuts Costs. M. C. Gillis. *World Oil 152,* 71 (1961) Mar. (3 pp.)

Pan American Petroleum Corp. engineers have developed an automatic system for removing water from low-pressure gaswells in the Hugoton area of Oklahoma and Kansas. Three such systems have been installed and all are working economically and efficiently. Although no tests have been conducted on the wells outside of the Hugoton area, the system appears adaptable to producing water or condensate from higher pressure, deeper gaswells, where normal flow rates are too low to produce liquids by conventional flow-through tubing.

Modern Well Completion Series. Part 10B. Permanent-Type, Multiple and Tubingless Completions. T. A. Huber and C. B. Corley, Jr. *Petrol. Eng. 33* (Drilling and Producing), B-57 (1961) Mar. (5 pp.)

Term "multiple completions" refers to the technique that permits two or more reservoirs to be produced simultaneously but separately through the same well bore. Although most multiple completions are used only for production, many wells of this type serve as multiple injection wells for pressure maintenance or secondary recovery projects, and others are used for the injection of fluid into one or more reservoirs while maintaining production from others.

Sidetracks Mark Tough Road in Deep Oklahoma Well. L. A. Murphy. *Petrol. Eng. 33* (Drilling and Producing), B-24 (1961) Mar. (5 pp.)

Three and one-half years and $4 million had gone into the search for deep production in the Anadarko Basin well No. 1 in Caddo County, Okla. But on August 2, 1959, after a long series of costly mishaps, the hole was abandoned after drilling to 21,021 feet. On December 15, 1959, the cement plug at the surface was drilled out, and the well was once more active. In November 1961, this well was again classified as "temporarily abandoned." Plans now are to reenter the well this month (March).

4. GAS CONDITIONING AND LPG RECOVERY

Carbon Dioxide Removal

Removing Acid Gas by Agitated Absorption. A. S. Moore and C. C. Shale. *U. S. Bur. Mines Rep. Invest. 5730.* (Washington: U. S. Govt. Print. Off., 1961)

Bureau of Mines is doing research and development work on removing acid-gas impurities from synthesis gas made directly from coal. The efficacy of the agitated contactor for absorbing carbon dioxide in diethanolamine increased with increasing solution rate, turbine speed, diethanolamine concentration, and carbon dioxide concentration in feed gas, and with decreasing liquid-gas ratio. It was unaffected by pressure between 200 and 300 psig and little affected by temperature between 115° and 190°F. Correlation of these factors by performance curves developed from statistically derived equations showed the agitated contactor to be an effective gas-contacting unit. Carrying capacity of the absorbent decreases as percent carbon dioxide removal increases. Scrubbing rates to 6 CF of carbon dioxide absorbed per gallon of solution and removal of to 98 percent of carbon dioxide in feed gas indicated the agitated contactor is suited to gross acid-gas removal.

Dehydration

Devices for Removing Moisture from the Flow of Gases. L. J. Goldsmith. U. S. 2,968,360 (1961) Jan. 17.

Device is claimed for removing moisture from a stream of flowing air or exhaust gases. Air enters through the screened end of a cylindrical housing, and is directed through a funnel with a whirling flow to a rear chamber lined with plates of fine-grained porous material such as sandstone. Moisture is absorbed and held by capillarity of stone.

Dust Removal

Gas Treating Device. R. W. Sexton (assigned to American Air Filter Co.) U. S. 2,966,958 (1961) Jan. 3.

Gas treating device is claimed that comprises a column containing a flat upper and a conical lower porous pad for intercepting dirt and washing liquid. An improved feature is a perforated conduit that dips into the wash-liquid oil at the bottom and extends to the column chamber below the first (conical) pad. Gas flowing through this conduit carries a film of oil up the pipe and disperses it in the gas. After removal from the gas by the conical pad, the oil flows to the pad periphery

and drains to the base sump for settling and recycling. The cleaned gas outlet is above the top pad.

Gas Washing Apparatus. M. B. Preeman (assigned to Standard Steel Corp.) U. S. 2,969,851 (1961) Jan. 31.

Apparatus is claimed for washing air or gases to remove dust or pollutants. This comprises a horizontal flow chamber where entering gas, baffled into a helical path, is sprayed with wash liquid. The washed gas then enters the base of an upright stack through a centrifugal separator, built as an annular chamber. Multiple ports in stack base allow flow into the stack, where gases may receive additional spraying.

Hydrocarbon Removal

How to Save Horsepower on Propane Refrigeration System Design. K. D. Robirds and J. C. Martin III. *Petro/Chem Eng. 33,* C-23 (1961) Mar. (3 pp.)

For various reasons, the large majority of gasoline plant process refrigeration is still supplied by reciprocating-type propane systems. These are usually considered to be rather stereotyped in design, but there are a few important choices that vary with the individual case. Depending on the temperature level involved and the refrigeration load, the use of a refrigerant vapor-liquid heat exchanger or an interstage liquid flash tank may prove advantageous.

Hydrogen Sulfide Removal

Modern Trends in Gas Purification. J. J. Priestley and W. E. Bouch. *Gas World 153,* 208 (1961) Feb. 4 (5 pp.)

Changes in methods have resulted in the concentration of production units at fewer and larger works, generally of the orthodox type based on the production of coal gas by carbonization and water gas by coke gasification. The bulk of gas sold in Great Britain is still manufactured in this way. Problems associated with traditional methods of purification are mainly due to increase in the scale of operation combined with the need to operate at the maximum possible efficiency. Over and above this factor, however, is the threat to established processes due to the change in markets for byproducts because of foreign imports and synthetic processes.

Process and Apparatus for Dry-Process Adsorption of Hydrogen Sulfide from Coke-Oven Gases. A. Steding and R. Muller (assigned to Didier-Werke A.G.) U. S. 2,967,587 (1961) Jan. 10.

Removal process for hydrogen sulfide is claimed for coke oven gas. A fresh, dry absorbent packing, such as iron oxide, is first exposed to the coal gas weak in H_2S content, then to the gas stronger in H_2S content. The absorbent then is contacted with oxygen-containing gas with low H_2S, thereafter contacted with high H_2S gas, and finally switched to a repacking position. The switching of positions of the various packings is accomplished by inlet and outlet valves and piping.

Sulfur Recovery from Petroleum Gases. R. A. Graff. (New York: ASME Paper No. 60-PET-29; 7 pp. $1.00/copy; $0.50 to members.)

Current sulfur recovery practices are reviewed and evaluated, as applicable to the conversion of hydrogen sulfide to elemental sulfur. Simplified flow diagrams covering three types of commercial processes are presented. Information covering general equipment design is included, as well as methods for handling the recovered sulfur product. Data covering the probable plant investment and processing costs are also presented.

Work Study as Applied to Oxide Handling on Tower Purifiers. O. W. Ault and P. L. Henderson. *Gas J. 305,* 157 (1961) Feb. 1 (4 pp.); *Gas World 153,* 278 (1961) Feb. 18 (3 pp.)

Purification and disposal of the additional quantities of gas at Scunthorpe steelworks (Great Britain) demanded the installation of additional purification and compressing plant, and additional trunk distribution mains against a tight time schedule. Work on "rapid rotation" has shown that oxide may be worked up to a sulfur content appreciably higher than the traditional 50 percent and a figure of 60 percent may well be attainable. The higher sulfur burden in spent oxide gives considerable financial advantage to the purification processes since not only are current tariffs biased in favor of a higher percentage of sulfur and transport costs on spent oxide reduced, but a smaller quantity only of new material need be purchased to purify a given quantity of crude gas.

5. NATURAL GAS TRANSMISSION

Compressors

Designing Compressor Foundations for Sandy Soil. R. E. Means. *Pipe Line Ind. 14,* 26 (1961) Feb. (4 pp.)

Static loading of compressor foundations is accomplished by vibration; this can cause settling in sandy soils and lead to excessive stresses in pressure piping. Knowledge of soil characteristics, effect of loading, vibration and settlement action will help minimize this hazard in station design. Tests and design examples are presented in simplified engineering terms.

Engines

Economic Development of Prime Movers Using Natural Gas Fuels. R. F. Moser and R. M. Greene. (New York: ASME Paper No. 60-PET-39; 8 pp. $1.00/copy; $0.50 to members.)

Objective of study reported is to review past and possible future developments in gas engines and gas turbines, and to indicate the significance of these developments on the economics of each.

Magnetic Particle Inspection at Regular Intervals Can Prevent Major Troubles. S. Vance. *Pipe Line Ind. 14,* 30 (1961) Feb. (3 pp.)

Critical engine and compressor parts require inspection and maintenance. Crossheads, for example, often develop cracks around the pin holes; piston rods develop fatigue cracks in the threaded sections where they have been galling at the stuffing box. This galling is evidenced

initially by minute fatigue cracks which eventually develop into peeling. Connecting rod stud and bolts as well as head studs and bolts develop fatigue cracks in the threaded sections. Keyways on shafts and crank pins are also critical areas. The magnetic particle inspection method is suitable for the inspection of all ferrous parts.

Maintenance of Turbocharged Engines Including Large and Medium Sized Units in Gas Transmission, Petrochemical and Gas Processing Plants. J. H. Caldwell. (New York: ASME Paper No. 60-PET-31; 8 pp. $1.00/copy; $0.50 to members.)

Purpose of paper is to supplement material in the author's book, "Practical Preventive Maintenance for Gas Engines," published in 1951, with information regarding the maintenance of engines employing turbochargers and centrifugal blowers.

New Controls Step Up Efficiency of Compressor Engines. J. M. Ranck. *Oil Gas J. 59,* 161 (1961) Mar. 13 (5 pp.)

New automatic mixture and speed-control system has proved to be highly successful on a turbocharged four-cycle, 1800-hp gas engine driving a pipeline compressor. Savings in fuel make it a self-paying system, with the average installation expected to return the initial investment in 1-2 years. New system is now being studied for application on recent-model two- and four-cycle engines of larger size. There seems to be no reason why similar savings cannot be effected.

The Low First Costs and Many Benefits of Ebullient Cooling. H. W. Evans. *Pipe Line Ind. 14,* 33 (1961) Feb. (4 pp.)

Ebullient cooling systems are a highly controversial subject. Article presents some of the pros and cons. Arguments in favor include: increased thermal efficiency; lower initial cost; more dependable operation; lower maintenance costs; better cooling; less oil contamination; better lubrication; reduced engine wear; and less downtime.

Fluid Flow

Boosting Pipeline Flow Efficiency. A. W. McAnneny and L. C. Sullivan. *Oil Gas J. 59,* 141 (1961) Mar. 13 (5 pp.)

Trunkline Gas Co. conducted a series of tests to compare sandblasting with pigging or in-place coating as a means of boosting pipeline flow efficiency. Tests showed that sandblasting gives a cleaner and more efficient pipe and that these efficiencies approach to within three per cent of the theoretical maximum.

Metering

Use of Turbine Type Meters for Pipeline Metering. W. W. Holt, Jr. (New York: ASME Paper No. 60-PET-43; 4 pp; $1.00/copy; $0.50 to members.)

Until recent years, the accepted measuring instruments for petroleum were positive-displacement-type meters. This system is satisfactory as long as the number of units is small. The need for larger capacity meters led to the development of the turbine type in sizes suitable for pipeline service. The details of the evolution of this meter and its operation form the context of the paper.

Pipeline Construction

Hill-Top Pipeline Installation Tests New Pipe Laying Techniques. W. Nickel. *Gas Age 127,* 19 (1961) Mar. 2 (4 pp.)

Mile-long link between two gas wells of United Fuel Gas Co. (Charleston, S.C.) is providing the eastern seaboard with its first demonstration of aluminum pipe as permanent, underground gas line. Installation under adverse conditions gave evidence of the flexibility of this type of pipe, and station welding permitted a weld and pull economical method of pipe laying. Soil conditions are expected to provide a stiff test of the corrosion resistance characteristics of the line over a period of time.

It Flies Through the Air with the Greatest of Ease. D. M. Taylor. *Pipe Line Ind. 14,* 38 (1961) Jan. (3 pp.)

Article describes the use of a helicopter in aerial stringing in the South Texas rice fields along the Transcontinental Gas Pipe Line Corporation's right-of-way just west of Houston. Frequent rains had turned this area into an almost impassable bog. Helicopter was used to string two-ton joints of 30-inch pipe. On the first day of aerial stringing, the helicopter delivered 85 joints of pipe to the right-of-way; on the second day, the total was 150 joints; and final tally was 210 joints on the third day.

Methods Are Matched with Terrain to Speed Building of Midwestern's Northern Line. H. C. Bozeman. *Oil Gas J. 59,* 133 (1961) Mar. 13 (4 pp.)

Midwestern Gas Transmission's new 495-mile, 24-inch line from the Minnesota-Canada border to Marshfield, Wis., crosses three distinct, different terrains. Company matches these conditions by combinations of double jointing, external wrapping, and field techniques.

New Tool Bevels Cement-Lined Pipe. W. B. Bleakley. *Oil Gas J. 59,* 180 (1961) Mar. 13 (2 pp.)

Cement-lined pipe, useful in fighting corrosion, has been a problem for the welder or the field man trying to maintain an unbroken lining in a water-injection or disposal system. Phillips Petroleum Co. has found a way to cut, bevel and weld cement-lined pipe and still have continuous protection from salt water or other corrosive fluids. New beveling tool uses an abrasive grinder driven by a pneumatic motor.

Pipeliners Whip Heavy Surf and Coral to Lay Offshore Hawaiian Lines. R. L. Bowman and J. H. Bevis. *Pipe Line Ind. 14,* 33 (1961) Jan. (5 pp.)

Two problems had to be solved before two submarine lines—a 20- and a 30-inch—could be laid two miles out into the Pacific Ocean from Barber's Point near Honolulu. Most difficult problem was to overcome the effects of the pounding surf that could exert up to 600 lb/lineal foot to displace them. The other was to blast a ditch through about 4000 feet of coral and smooth it so a pipeline could be pulled through it without damaging the concrete coating. Purpose of the two lines is to link Standard Oil Company of California's new 35,000 bbl/day refinery with an offshore mooring facility for giant seagoing tankers.

TGT, Pemex Draft Final Pipeline Contract. *Oil Gas J. 59,* 92 (1961) Mar. 13.

Tennessee Gas Transmission Co. and Petroleos Mexicanos have completed work on the final wording of contracts for the Texas-Mexico-California gas pipeline. Included in the deal is a $15 million prepayment to Pemex for a separate gas pipeline to serve Monterrey. The money will be used to construct a line from the Poza Rica fields in the Tampico area northward to Monterrey. The city currently gets gas via a 12-inch line from Reynosa, also the source of Mexican gas being dedicated to the Tennessee Gas-Pemex line. Still to be approved, however, are applications by Tennessee Gas before the California Public Utilities Commission and the Federal Power Commission (see abstracts, pages 49, 52).

Trans-Southern LP-Gas Pipeline Crossing Tombigbee and Tallapoosa Rivers. *LP-Gas 21,* 21 (1961) Mar. (2 pp.)

Beginning this fall the Trans-Southern LPG pipeline will move up to 60,000 bbl/day of propane and butane from Louisiana and Texas to terminals near markets in Mississippi, Alabama, Georgia, South Carolina, North Carolina, Virginia, Florida and Tennessee. No pipeline now provides this service. The pipeline will have such unusual features as underground storage caverns near Atlanta, with a combined capacity of one million barrels.

Pipeline Operations

These 5 Steps Show How to Repair Operating Pipeline. J. P. O'Donnell. *Oil Gas J. 59,* 155 (1961) Feb. 20 (4 pp.)

Replacing a section of an operating 24-inch crude-oil pipeline can be a routine matter. But, when it is undertaken on an isolated location in the Sahara with sandstorms and inexperienced help, it can pose some very real problems. The SOPEG line from Algeria's Hassi Messaoud field to the Mediterranean port of Bougie has been in operation since late 1959. During its first year of operation, a number of leaks developed. They were concentrated in a 20-km section of the pipe which had a poorly welded seam. Author discusses steps used in repairing the operating line.

New Method for Locating Electrical Shorts and Open Couplings. D. D. Byerley. *Pipeline Eng. 33,* D-24 (1961) Mar. (4 pp.)

Usual technique used to locate underground electrical contacts and open couplings on coated pipelines has been to apply an audio frequency signal between the coated pipeline and a good earth ground. An improvement in this method can be made with substantially the same equipment, enabling the operator to locate the actual point of contact with a greater degree of accuracy and a considerable saving of time. Disturbance of the null rather than the signal level of audio frequency is the basis of the improved procedure.

River Crossing Pipe Passes Tough Inspection. D. G. DePugh. *Pipe Line Ind. 14,* 41 (1961) Mar. (4 pp.)

Striving for a near perfect submarine river crossing, Columbia Gulf Transmission Company made complete inspection of the pipe before construction. Ultrasonic tests for wall thickness, magnetic particle external surface and visual internal surface tests found several sections of pipe that had to be rejected. The dual 24-inch 0.500-inch wall river crossing was buried 40 feet under the Mississippi River near Mayersville, Miss.

Plastic Piping

Field Reports from 5 Utilities. W. E. Mickelson, H. J. Taylor, Jr., P. W. Rogers, J. F. Fugazzi and J. E. Wright. *Gas 37,* 93 (1961) Mar. (8 pp.)

Five utilities report experiences with plastic pipe in brief, individual summaries. Facilities reporting include: Central Electric & Gas Company (Lincoln, Neb.); City Utilities of Springfield (Mo.); The Ohio Fuel Gas Company (Columbus); Public Service Company of Colorado (Denver); and The Gas Service Company (Kansas City, Mo.)

Plastics Pipe at Phillips. R. M. Weaverling and L. B. Croley. *Gas 37,* 135 (1961) Mar. (3 pp.)

At the present time, Phillips Petroleum Co. is using more than 1.1 million feet of high-density polyethylene pipe in its gas gathering and distribution service. As a result of a massive five-year test program, company has now made it standard practice to use plastic pipe in all applicable operations, including salt water disposal, water supply and crude oil gathering lines as well. Article discusses program with special emphasis on butt fusing plastic pipe.

Plastics Pipe Shows Plenty Progress! R. Clay. *Gas 37,* 89 (1961) Mar. (4 pp.)

Predictions for plastic pipe indicated that 1960 usage would range from 2.46 to 2.8 million feet. Figures indicate that actual consumption totaled 3.23 million feet during the year. Estimate for 1961 is 4.53 million feet, an increase of 83.9 percent over the 1960 estimate. Translated into other terms, the 1961 estimate is 858.7 miles. However, author predicts that the total may actually exceed 1000 miles.

Welding

Automatic Welding for the Right of Way. M. A. Judah. *Pipe Line Ind. 14,* 26 (1961) Mar. (4 pp.)

Process described features a CO_2 gas shield, and uses no flux. The pipe is not rotated during a weld, and in recent tests it proved highly successful on the right-of-way. The welds are equal to manual welds in strength. There are no slag inclusions (because no flux is used) and the only off-specification feature of the welds is the small size. Inclement weather does not curtail the operation of the unit.

Stress-Relieve Welds by Combustion. *Petrol. Refiner 40,* 121 (1961) Feb. (2 pp.)

New method of stress-relieving field welds is similar to the match-fired, self-vulcanizing tire patch—simply wrap the material plus insulation around a weld to be stress-relieved, light it with a torch and walk away. The

annealing temperature is automatically controlled by the burning process. The combustible material consists primarily of aluminum powder, metal oxides, refractory materials and binders which are formed into half cylinders corresponding to the pipe size being stress-relieved.

Grinding for Stringer-Bead Preparation Insures Better Pipeline Welding. A. G. Barkow. *Oil Gas J. 59,* 149 (1961) Mar. 13 (6 pp.)

Gross cost of welding is reduced, including cost of weld repair. It has been found that high-heat cutting is not required in running the hot pass, so it can be run faster. The root bead as well as all other beads must be cleared before the next bead is applied.

6. GAS AND LPG STORAGE

Methane Liquefaction

Expansible-Wall Container for Low-Temperature Fluids. W. L. Benson and N. C. Dahl (assigned to Conch International Methane Ltd.) U.S. 2,971,667 (1961) Feb. 14.

Improved tank for liquefied natural gas is claimed which comprises an improved expansible wall construction. The wall is formed of a number of pan-shaped rectangular members, press-formed to curve outward. The pans are placed side by side and end to end to form a rectangular wall, and are joined at the pan-rims (which face inward) by welding. Thus, two adjacent sides of a pair of pans form a V-shaped bellows fold, with the welded joint at the fold, thus giving flexibility of the wall against contraction and hydraulic head.

Liquid Methane Behind the Iron Curtain. C. I. Kelly. **Part 1.** *Petrol. Times 64,* 817 (1960) Dec. 2 (2 pp.); **Part 2.** *Petrol. Times 65,* 97 (1961) Jan. 27 (2 pp.)

Part 1 presents data on the technical aspects of the LSR plant in Moscow, originally designed for V/D Technopromimport, a USSR governmental agency. Part 2 discusses the distribution and use of liquid methane derived from the plant, including its use in road vehicles.

Liquid Storage Tanks and Attachments. J. J. Henry (assigned to Conch International Methane Ltd.) U. S. 2,970,604 (1961) Feb. 7.

Method and means are claimed for filling and discharging of storage tanks with cold-boiling liquefied gas. Vertically spaced contacts are provided on the interior tank wall with connections to indicator means on a pump house panel to show filling progress. A top level contact is arranged to stop the pump. A pressure and vacuum detecting switch also is provided to shut off the pump at dangerous levels.

Method and Apparatus for Containing a Liquefied Gas. H. L. Johnston (assigned to Herrick L. Johnston, Inc.) U. S. 2,969,092 (1961) Jan. 24.

Improved insulated construction is claimed for walls of containers for low-temperature liquefied gases. This comprises a heavier inner metal wall for directly containing the liquid, a thin stainless steel sheet or foil outer wall spaced around the inner wall, and an insulation of gas-permeable material such as block cork, glass fiber, etc., filling the annular space between walls. The insulation is continuously pumped to a low vacuum whereby atmospheric pressure holds the insulation against the inner wall.

Storage

Bulk Helium Transportation. L. A. Bliss (assigned to Union Carbide Corp.) U. S. 2,968,161 (1961) Jan. 17.

Improved transportation tank for storage of gaseous helium is claimed. This comprises one or more cylinders of 9 percent nickel steel refrigerated by a bath of liquid nitrogen (argon, methane). The bath is sealed in a thermally insulated vessel. Strength of alloy permits use of 3140 psi pressures and storage of 2.5 times the amount usually stored at 2200 psi.

Tankers

First Refrigerated LPG Tanker Being Built. *Oil Gas J. 59,* 79 (1961) Mar. 6.

Japan is building the world's first refrigerated tanker to move liquefied petroleum gases to be used in the petrochemical industry and as bottled gas in that country. Ship with a capacity equivalent to about 17,000 tons of refrigerated LPG at about –40°F and service speed of 16 knots, was designed by Conch International Methane, Ltd.; construction is by Mitsubishi Nippon Heavy Industries (Yokohama) Ltd.

Underground Storage

CG&E Digs Again for Second Huge Storage Cavern. *A.G.A. Monthly 43,* 16 (1961) Feb. (3 pp.)

Cincinnati Gas & Electric Co. is digging a huge liquid propane storage cavern 450 feet underground—the second multimillion dollar subterranean gas service project to be installed in its southwestern Ohio, northern Kentucky service area. The new cavern is being mined beneath a steep hillside about five miles west of Covington, Ky. This $1-million project will be followed by the construction of a $2-million gas processing plant.

Method of Sealing Off Flow from Underground Storage Cavern and Apparatus. L. P. Meade (assigned to Phillips Petroleum Co.) U.S. 2,971,344 (1961) Feb. 14.

Emergency method is claimed for controlling flow of gas from an underground storage cavern under high pressure. A high-pressure water supply is provided to direct water to subsurface pipes leading to the gas outlet sump. Here the water is continuously pushed upward by the cavern pressure and fills the vertical column of the outlet to offset gas pressure to seal off any flow.

Washing Out Salt Dome Ticklish. *Petrol. Week 12,* 72 (1961) Feb. 17 (2 pp.)

Sohio Pipe Line Co. is encountering, and apparently solving, some tricky problems in developing two caverns for propane storage in a salt formation in Cleveland. The underground wells, which will have a total capacity of 80,000 bbl, are being washed out of a salt bed.

7. MANUFACTURED GAS AND CHEMICAL PROCESSING

Aromatics

Some Aspects of Benzene Production. D. Bradley. *Gas World 153,* (Coking Sect.) 12 (1961) Feb. 4 (3 pp.)

Discussion covers the production methods available to meet the increasing demand for pure benzene, conforming to more stringent specifications. Benzene is the most abundant nongaseous compound produced from coal and as such it has become an important reagent in the synthetic chemicals industry.

Catalysts

Selection and Evaluation of Contact Catalysts. E. H. Lee. *Ind. Eng. Chem. 53,* 205 (1961) Mar. (4 pp.)

Modern theory and research tools permit selection and evaluation of contact catalysts on a more scientific basis than possible in previous times. However, many precautions are necessary in attempting to relate catalyst properties and their performance. A systematic approach to such work is described, with reference to the available techniques and approaches in the literature.

Coal Carbonization

A Continuous Process for Low Temperature Fluidized Carbonization of Coal. S. K. Mukherjee, M. Sen, A. K. Das Gupta and A. Lahiri. *J. Sci. & Ind. Research 19A,* (1960) Dec. (5 pp.)

Continuous process for low-temperature carbonization of noncaking coals in a fluidized bed is described. Preheated air is used as the fluidizing medium, and the heat for carbonization is obtained by combustion of a part of the coal and char inside the carbonizer, which is electrically heated. A suitable condensing system to recover the byproducts is provided. Experiments have been carried out with coal feed rates varying from 15 to 36 lb/hr and air-to-coal proportions of 5 and 7 cu ft of air/lb of coal. The carbonization temperature has been found to be a function of the coal feed rate and the air-to-coal ratio. The average yield of tar is about 8 percent and the char yield varies from 65 to 74 percent with Jambad-Bowlah coal of the Raniganj (India) coalfield.

Cessnock—A New Works "Down Under." *Gas J. 305,* 136 (1961) Jan. 25 (2 pp.)

Cessnock gasworks, the first complete new gasworks erected in New South Wales, Australia, since 1913, is located in the center of rich coalfields. Four benches of eight machine-charged retorts have been installed, with space for two more benches, and plant capacity is estimated at 625,000 CF/day, using coal with 42 percent volatiles.

Method in Pyrolyzing and Burning and a Shaft Furnace for the Execution Thereof. A. R. L. Brandeberg (assigned to Svenska Skifferoljeaktiebolaget). U. S. 2,967,133 (1961) Jan. 3.

Method of pyrolyzing shale and coal in a vertical shaft heated retort is claimed. Method comprises improved heating by burning with air in a base section the heated residue from the open bottom of the retort and injecting added fuel such as gas into the top of the spent fuel bed. Sintering of spent residue is offset by cooling coils below the top of the combustion bed.

Coal Gasification

A Down-Draft Coal Gasification Pilot Plant. M. Sen, A. K. Das Gupta, D. Mukerjee, S. C. Ghosh, J. R. Mitra and A. Lahiri. *J. Sci. Ind. Research 20D,* 4 (1961) Jan. (8 pp.)

Downdraft coal gasification pilot plant, designed and fabricated to study suspension gasification of noncoking, high-volatile Raniganj coals, is described. The effect of these variables on gasification characteristics has been investigated: 1) feed rate; 2) oxygen enrichment; and 3) oxygen-to-coal ratio. The optimum feed rate and oxygen enrichment for the plant are 75 lb/hr and 50 percent, respectively. Under the optimum conditions, the heating value of the gas produced and the amount of carbon gasified attain the maximum values of 160 Btu/CF and 50 percent, respectively.

Ethylene

Process and Apparatus for Producing Acetylene and Ethylene. C. J. Coberly (assigned to Wulff Process Co.) U. S. 2,967,205 (1961) Jan. 3.

Regenerative furnace and method for pyrolysis of hydrocarbons are claimed. The furnace comprises three refractory regenerative masses spaced in a horizontal casing to provide two "center spaces" for gas and two outer-end gas-collecting chambers. The center and either the right or left refractory mass are preheated by a fuel burning in the left or right combustion space, and passing through longitudinal channels through the mass. A closed-box cooling device fills the entire cross section of this combustion space, and is perforated by multiple flues to permit flow of combustion gases. The combustion space is cooled by baffled flow of "Dow Therm." After preheating to 2200°F, propane-steam is injected at one end, is warmed in the first (left) mass, pyrolyzed to ethylene in the center mass, is rapidly cooled in the right cooling box, and leaves by the second (right) mass. Ethylene (or acetylene) is removed, and the off-gas is recycled for fuel.

Helium

Helium Production at the Bureau of Mines, Keyes, Okla., Plant. W. M. Deaton and R. D. Haynes. *U. S. Bur. Mines, Inf. Cir. 8018.* (Washington: U. S. Govt. Print. Off., 1961; 16 pp.)

Keyes Helium Plant of the Federal Bureau of Mines was constructed under an expedited schedule, to supply the urgent and growing demand for helium in atomic energy, missiles, aerology, space exploration, shielded-arc welding, and low-temperature research. Construction began in December 1958 and ended in August,

1959. The plant, near Keyes, Okla., processes 2 percent helium-bearing natural gas from the Keyes gasfield. In 1960 the plant produced and shipped 263 MMCF of helium (equivalent to an annual rate of 290 MMCF). Production cost was $9.11/MCF of helium.

Hydrogen

For Cheap Hydrogen, Try Adsorption. *Chem. Eng. 68,* 72 (1961) Mar. 6 (2 pp.)

New hydrogen generator turns out 95 percent or purer product from dissociated ammonia—and does it, according to the manufacturer, below the cost of equal purity hydrogen produced in plants requiring much larger capital investment. Using neither low-temperature distillation nor precious metal membrane separation, the plant employs a simple adsorption process that is based on the affinity of activated charcoal for nitrogen.

How to Make More Hydrogen Cheaper. *Petrol. Week 12,* 53 (1961) Mar. 10.

To meet the rising demand economically, significant improvements have been brought to the most common method of producing hydrogen: the catalytic reaction of steam and light hydrocarbons. The basis of the process has not been changed; it consists of reacting a preheated mixture of steam and light hydrocarbon gas over a nickel catalyst at high temperature. Improvements are in terms of improved catalysts, tube metallurgy and in furnace design, particularly with regard to more effective heat distribution.

Hydrogen Sulfide

Production of Lime and Hydrogen Sulfide. P. S. Viles (assigned to Esso Research and Engineering Co.) U. S. 2,970,893 (1961) Feb. 7.

Method is claimed for producing lime and hydrogen sulfide in which finely divided gypsum (calcium sulfate) is contacted with natural gas and steam in the presence of a cobalt molybdate catalyst at 1200°-1400°F. The H_2S is scrubbed from off-gases in an absorption zone, and the lime is separated from the catalyst by gravity.

Nitrogen Oxides

The Catalytic Treatment of Nitric Acid Plant Tail Gas. H. C. Andersen, W. J. Green and D. R. Steele. *Ind. Eng. Chem. 53,* 199 (1961) Mar. (6 pp.)

Catalytic treatment of nitric acid plant tail gases containing O_2, NO, NO_2 and H_2O in N_2 was investigated. With one or more metals of the platinum group as catalysts, the oxides and oxygen are reduced to a few parts per million at space velocities of 60,000 standard cubic feet per hour per cubic foot catalyst and higher, using any reducing gas in slight excess over the total oxygen. Two catalytic stages with intercooling are used, to obviate excessive temperatures on the catalyst and vessel, when the O_2 is greater than 2.8 to 4.2 percent. With a fuel deficiency, catalytic treatment may also be employed to yield heat without air pollution abatement. A selective catalytic process for nitrogen oxides removal is described: NO and NO_2 are reduced by ammonia in slight stoichiometric excess over these oxides but far below the total oxygen equivalence.

Petrochemicals

Trends to Watch in Phthalic Anhydride. J. Gordon. *Petrol. Refiner 40,* 139 (1961) Feb. (6 pp.)

Phthalic anhydride (PA) producers are looking forward to new raw material supplies from petroleum refiners. A group of refiners, in a petrochemical activity reminiscent of the polyethylene boom, are erecting facilities to recover naphthalene or ortho xylene made in catalytic reformers. Either one of these products is suitable for making phthalic anhydride, which repeatedly has been in short supply.

Versatile Chlorinated Hydrocarbons. R. K. Treichler. *Oil Gas J. 59,* 112 (1961) Mar. 6 (3 pp.)

Chlorinated hydrocarbons have had an interesting history. The center of manufacture has moved from the Northeast to the Gulf Coast and back to the Northeast during the past twenty years. Annual production of chlorinated hydrocarbons was about 3.25 million pounds in 1960, and this is expected to increase to 4.5 million pounds by 1970. Today, there are some 44 major plant locations in the United States in 31 cities producing chlorinated hydrocarbons. In 1960, production from these installations was about 3,250,000,000 lb.

Pyrolysis

Thermal Stability as a Function of Chemical Structure. E. S. Blake, W. C. Hammann, J. W. Edwards, T. E. Reichard and M. R. Ort. *J. Chem. Eng. Data 6,* 87 (1961) Jan. (12 pp.)

There is no systematic recording of the chemical literature of the thermal stability of organic compounds under the same conditions. Many of the data are based on the stability of a material passing through a hot tube and on observations made upon distillation. Paper reports on a comparison under the same conditions of the thermal stabilities of over 100 organic compounds in 12 chemical classes and the relation of these data to structure. The test method and a large portion of the data reported resulted from a search for materials with a minimum thermal stability of 700°F.

Reformed Gas

Method of Heating and Reforming Hydrocarbons and Other Gases. J. D. Madaras (assigned to Gas Inc.) U. S. 2,971,752 (1961) Feb. 14.

Method of heating gases is claimed which comprises preheating a checker heater to high temperature, then introducing the gas to be heated at a higher pressure, raising the pressure and exhausting the heated product gases. Pulsation of the second gas stream is emphasized in obtaining better heat transfer. Preheating of hydrocarbon gas for reforming or cracking is mentioned.

Tar

Sulzer Tar Condensation. A. Meyer. *Gas J. 305,* 195 (1961) Feb. 8 (3 pp.)

Several oil gasification methods have been developed in recent years, all of them based on the principle of thermal cracking. In most cases, however, difficulties of a more or less severe nature are encountered in the removal of the condensed tar vapors and the carbon from the raw gas. British firm claims solution to this problem in the form of the Sulzer washer. Method is said to combine greater reliability with reduced space requirements.

8. GAS DISTRIBUTION

Cathodic Protection

New Truck for Anode Installation. *Gas 37,* 87 (1961) Mar. (2 pp.)

Northern Illinois Gas Co. is conducting field tests of a recently designed truck body featuring a boom-hung, hydraulically powered earth auger. If successful, the equipment will be used for cathodic protection operations. Hydraulically operated boom is pedestal-implaced high on the curbside rear of a conventional truck bed. The boom can be rotated and extended under control. Full boom extension is about 18 feet, permitting anode holes to be bored without moving the truck to the immediate vicinity of the gas pipeline or main.

Distribution Systems

Britain's First Town to Be Supplied with Natural Gas. J. Grindrod. *Gas Age 127,* 32 (1961) Mar. 2 (4 pp.)

Since the Fall of 1960, Whitby, Yorks, has been supplied with natural gas from two wells some six miles distant and has become the first entire town in the United Kingdom to be supplied with natural gas for domestic and industrial use. Introduction of natural gas in a British community emphasizes the unique problems faced by the British in providing gas service. Supply is not assured. Consequently, gas analysis must be arrived at with coal gas quality in mind. Meaning of this is described by author.

How to Cut Down Gas Losses. G. Gutte. *Gas J. 305,* 199 (1961) Feb. 8 (5 pp.)

According to their origin, gas losses from the producer enroute to consumer can be divided into three main groups: 1) changes in gas condition; 2) metering faults; and 3) pipeline losses. Present article deals with the gas losses under the first heading; subsequent articles will discuss the remaining categories.

Telemetering

Just What Is Data Handling? F. V. Long. *Gas 37,* 143 (1961) Mar. (5 pp.)

Author attempts to resolve the meaning of "data handling" by quoting experts in the field, and comes to the conclusion that no matter how it is defined, telemetering is an implied or explicit, but always vital link, in any data processing system.

9. GAS FUEL UTILIZATION AND APPLIANCES

Air Pollution

A Method for Determining Source Reduction Required to Meet Air Quality Standards. R. I. Larsen. *J. Air Pollution Control Assoc. 11,* 71 (1961) Feb. (6 pp.)

In order to determine the relative atmospheric concentration of the several exhaust components which may cause smog, it is sufficient to measure the atmospheric concentration of only one exhaust constituent, providing these requirements are met: 1) the measured constituent should be capable of accurate measurement; 2) it should originate primarily from autos; 3) it should not react readily in the atmosphere. Carbon monoxide fulfills these requirements. Air pollution source data indicate that approximately 85 percent of all carbon monoxide emitted to the Los Angeles basin is from motor vehicles.

An Appraisal of Air Pollution in Minnesota. [Prepared by the Minnesota Dept. of Health with the cooperation of the U. S. Dept. of Health, Education, and Welfare, Public Health Service. (Minneapolis: Minnesota Dept. of Health; January 1961; 73 pp.)]

Presented in eight technical sections, report places greater emphasis on presentation of data than on interpretation, but it does point out that air pollution exists in Minnesota in sufficient degree to merit further consideration. Survey had these objectives: 1) to assess the nature and extent of air pollution in the state; 2) to inventory and summarize existing state and local legislation relating to air pollution; 3) to assess present air pollution activities in the state; 4) to provide a basis upon which state and local agencies may determine the most suitable type of legislation; and 5) to provide a basis upon which the state and local agencies may determine the type and extent of activities that should be undertaken.

An Interim Report on Full-Scale Study of Dispersion of Stack Gases. F. E. Gartrell, F. W. Thomas and S. B. Carpenter. *J. Air Pollution Control Assoc. 11,* 60 (1961) Feb. (7 pp.)

Interim review of a full-scale study of dispersion of stack gases from large coal-burning power plants which was initiated in July 1957 is presented. When the Tennessee Valley Authority initiated construction of the first of a number of large coal-burning power plants in 1951, due attention was given to air pollution control. The constituent of flue gas emissions of special interest was sufur dioxide. Extensive use was made of automatic stationary recording SO_2 samplers, Thomas autometers, to monitor ground concentrations. Early in TVA experience it became obvious that commonly used diffusion equations were generally unreliable for estimating dispersion of power plant stack gases. Accordingly, the Titrilog was adapted for operation in Bell Model 47-D-1 helicopters which are used for power line patrol and mosquito control operations in TVA.

Application of Air Quality Standards to a Community Problem. B. D. Tebbens and D. H. Hutchison. *J. Air Pollution Control Assoc. 11,* 53 (1961) Feb. (4 pp.)

When ambient air quality standards are based on sound scientific data and are of such character as to eliminate known effects of air pollution on humans or their property, such standards are directly applicable to control of the air environment of a community. Application of authoritative standards removes prejudice and capriciousness from air pollution control, leaving for decision by a community such factual items as the economic value of a satisfactory air quality. A careful inventory of sources of contaminant, of existing contaminant effect in the community, and of meteorology and geography is necessary for estimating the cost and value of such procedure.

Atmospheric Emissions from Petroleum Refineries. Public Health Service Publication No. 763. (Washington, D. C.: U. S. Govt. Print. Off., 1960, 56 pp. $0.30.)

In September 1955 a study, known as the "Joint Project," was started to determine the quantity and nature of emissions from oil refineries located in Los Angeles County. The work of the Joint Project has been presented in nine reports. For each source studied these reports detail sampling and analytical techniques, results of field testing programs, data evaluation, techniques, and total emissions from the refineries in Los Angeles County. This manual supplements the Joint Project reports and stresses the use which can be made of the methodology and results of the Joint Project in estimating emissions from refineries.

Combustion Nuclei—An Index for Classifying Gaseous Hydrocarbon Fuels. J. E. Quon, B. D. Tebbens and J. F. Thomas. *Ind. Eng. Chem. 53,* 235 (1961) Mar. (4 pp.)

Method for calibrating a photoelectric nucleus counter together with its use for the classification of simple hydrocarbons fuels is presented. A maximum nucleus-free fuel rate, characteristic of the beginning of carbon formation, was found for each fuel. The reciprocal of this fuel rate was defined arbitrarily as the relative air pollution potential of a fuel. The photoelectric nucleus counter allows the classification of fuels at the inception of carbon formation. This is not possible with conventional smoking point tests.

Hydrocarbon Emissions from Automobiles. P. R. Lepisto, H. C. McKee, K. D. Mills and R. J. Wheeler. (San Marino, Calif.: Air Pollution Foundation, Report No. 32; 45 pp.; February 1961.)

Shortly after hydrocarbon emissions from motor vehicle exhaust were found to be an important factor in photochemical smog formation, attention was called to other automotive sources of hydrocarbon vapors, specifically crankcase blowby and carburetor and fuel tank losses. No data have been made available, however, on the total hydrocarbon emissions from the same motor vehicle. Accordingly, the Foundation contracted with Southwest Research Institute to measure the total hydrocarbon emissions from several automobiles. Report presents results of the study. Although only five cars were studied, it is believed data indicate the relative importance of various sources of hydrocarbon emissions from the total car population. The fact that 95 percent of the total hydrocarbon emissions come from exhaust and blowby is significant. Losses from the carburetor and fuel tank are insufficient to merit further attention.

Process Development in Removing Sulfur Dioxide from Hot Flue Gases. Part 1. Bench-Scale Experimentation. D. Bienstock, J. H. Field and J. G. Myers. *U. S. Bur. Mines Rep. Invest. 5735.* (Washington, D. C.: U. S. Dept. of the Interior, 1961; 29 pp.)

In connection with air pollution studies, the Bureau of Mines is cooperating with the U. S. Public Health Service in investigating the use of solids to remove sulfur dioxide in concentrations of less than 0.5 percent from combustion and waste gases. Results are reported of extensive investigation, using metallic oxides as absorbents, adsorbents, and oxidation catalysts at 130° and 330°C (temperatures at which flue gas may be treated in power plant practice). The most active absorbents tested were the oxides of manganese, cobalt, copper and alkalized alumina.

Refiners Continue Attack on Air Pollution. D. H. Stormont. *Oil Gas J. 59,* 106 (1961) Feb. 20 (11 pp.)

This year about $12,700,000 will be spent to control emissions from plants throughout the United States. This would bring the refiners' six-year investment up to a total of more than $105,000,000. Most of this year's expenditures will be earmarked for programs to curb hydrocarbons, either through combustion or by installing equipment for their recovery or control. Major portion of the hydrocarbons controlled will be saturated compounds.

Smog Control Decrees Less Olefins in Gasoline. M. J. Fowle, J. A. Nevison, C. D. Wrigley and M. Brill. *Oil Gas J. 59,* 130 (1961) Mar. 6 (5 pp.)

As the pressure for smog control grows, refiners may well be forced to limit the amount of olefins in gasoline. Los Angeles refiners are currently faced with such a regulation. It may spread. Faced with this prospect, Atlantic studied the effects such a move would have on processing and its cost.

Appliances

Design Factors of Gas Heating Appliances for More Effective Use of Heat Exchanger Surface. D. W. DeWerth and R. E. Smith. [A.G.A. Res. Bull. No. 86. (Cleveland: A.G.A. Laboratories; January 1961) 72 pp.; $2.50]

Heat transfer studies with tubular shaped and sectional-type gas-fired furnace heat exchangers showed the effects of flame aeration, quantity and direction of circulating air flow, internal flue baffling, and heat exchanger material of construction on heat transfer efficiency. Variations in coefficients of heat transfer were measured for both tubular shaped and sectional exchangers. Experimental application of the developed optimum heat transfer conditions to a tubular shaped exchanger produced a satisfactory 18.5 percent increase

in element loading. An engineering analysis of possible heat exchanger materials of construction showed that the exchanger wall material has very little effect on heat transfer. Original heat transfer data verified that at constant fuel input, increased cooling air velocities increased heat transfer effectiveness. Correlation of these data revealed that for each type of exchanger studied, the overall coefficient of heat transfer could be predicted by a simple equation for varying circulating air flows.

Burners

Industrial Gas Burner Equipment Basic Construction and Applications. D. G. Darling *Can. Gas J. 54,* 32 (1961) Jan. (2 pp.)

Completing his survey, the author explains the bar, radiant heat and gas-oxygen burners, discusses safety equipment and techniques for natural gas, and basic safety points for LPG.

Cookers

Cooking Appliances Burning a Gaseous Fuel. S. S. Axelsson (assigned to Aktiebolaget Bahco). U. S. 2,969,054 (1961) Jan. 24.

Cooking appliance combination is claimed, which comprises a casing containing a small fuel gas cylinder mounted vertically with a control valve at top. One side of the cylinder is flattened to form a burner with vessel support, pivoted at base of the casing to fold into a compact portable unit. A resilient tube, coiled at the level of pivot, connects the valve and burner.

Explosives

Research and Technologic Work on Explosives, Explosions, and Flames: Fiscal Year 1959. R. F. Brinkley and R. W. van Dolah. *U. S. Bur. Inf. Cir. 8000.* (Washington, D. C.: U. S. Govt. Print. Off., 1961; 35 pp; $0.60)

Circular summarizes the research and technologic activities and publications of the Federal Bureau of Mines Division of Explosives Technology during the period July 1, 1958-June 30, 1959. Part I briefly describes the programs that were active during the report period and presents a summary of some of the data not published elsewhere. Part II lists and discusses briefly the publications of the Division during fiscal 1959.

Flame Research

Ignition Temperature Approximation for Bimolecular Detonations. J. O. Hirschfelder, C. F. Curtiss and M. P. Barnett. *Phys. of Fluids 4,* 260 (1961) Feb. (2 pp.)

Theory of detonations including the effects of transport properties is applied to a detonation supported by the bimolecular reaction 2A→2B. For simplicity, the ignition temperature approximation is used and it is assumed that the Prandtl number is three-fourths and the Lewis number is unity. Very little difference is found between the properties of a bimolecular and a unimolecular detonation. However, because of the unrealistic nature of ignition temperature chemical kinetics, it is not possible to reach any conclusion regarding experimental gaseous detonations.

Effect of Chemical Reaction Order on Flame Propagation. J. O. Hirschfelder. *Phys. of Fluids 4,* 253 (1961) Feb. (7 pp.)

Flame properties supported by one-step exothermal chemical reactions of orders zero through third are compared. New calculations are made for flames supported by second- and third-order reactions. The ignition temperature approximation is developed for zero- and second-order flames.

The Flammability Limits of Moving Mixtures of Propane and Air. K. N. Palmer and P. S. Tonkin. *J. Appl. Chem. 11,* 5 (1961) Jan. (3 pp.)

Lower and upper flammability limits of propane/air mixtures flowing along a tube 6-4 cm. in diameter were determined for gas velocities up to 600 cm/s. At the lower end of the velocity range the limits were wider than with the static mixtures, particularly at the upper limit, but they narrowed again as the flow velocity was increased.

Industrial Heating

Brazing, Annealing and Soldering Operations in Automated Manufacturing of Coffee Percolators. A. Q. Smith. *Ind. Heating 28,* 268 (1961) Feb. (3 pp.)

Article briefly describes gas burners and furnace used in the various stages of manufacture of a coffee percolator.

Machine Brazing 600 Assemblies Per Hour in Tank Production at Automobile Plant. *Ind. Heating 28,* 274 (1961) Feb. (2 pp.)

Unique type of self-indexing machine silver brazes a tube and flange to a tank. Each of two such automatic units designed and built by Selas Corp. of America, comprises 20 stations for loading, heating, cooling and automatic unloading.

Multiple-Step Heat Treatment of Railroad Roller Bearings in Completely Automatic Continuous Cycle. *Ind. Heating 28,* 248 (1961) Feb. (11 pp.)

Columbus (Ohio) plant of Timken Co. recently placed in operation an automated plant for manufacturing five standard sizes of railroad roller bearings ranging up to 10 inches in diameter and 8 inches in length. Plant consists of three separately housed departments: 1) green machining department; 2) heat treating department; and 3) finishing department. Pusher-type carburizing and rotary hearth hardening furnaces are employed in the operation.

Radiant Firing Doubles Kettle Life. J. Atkinson. *Ind. Gas (Amer.) 39,* 7 (1961) Feb.

Life of a galvanizing kettle has been doubled by direct-firing with radiant gas burners at Clark Grave Vault Co. This was proved recently when their first radiant-fired kettle was replaced after eight years of almost continuous use. Previous experience in hot-dip galvanizing at this plant set maximum kettle life with conventional burners at about four years.

Nitrogen Oxides

The Effect of Sulphur Dioxide on the Combustion of Some Inorganic Compounds. Part 2. The Nitric Oxide + Sulphur Dioxide + Oxygen System. C. F. H. Tipper and R. K. Williams. *Trans. Faraday Soc. 57,* 79 (1961) Jan. (8 pp.)

Traces of nitrogen oxides are present in the exhaust fumes from internal combustion engines, and are thought to be the cause of certain unpleasant smog conditions in cities. This part presents the results of a study of the $NO+SO_2+O_2$ system (for Part 1, see *Gas Abstracts 17,* 36). There is still no agreement on the mechanism of the oxidation of nitric oxide to give nitrogen dioxide in the gas phase. Two suggestions have been made: 1) an intermediate compound is formed; 2) NO_2 is produced directly in termolecular collisions. The reaction of sulfur dioxide with nitric oxide and nitrogen dioxide has been investigated by others. Compounds such as SO_3. NO and $(SO_3)_2N_2O_3$ are formed.

Ovens

Industrial Ovens Have Great Versatility. H. G. Gehnrich. *Ind. Gas (Amer.) 39,* 8 (1961) Feb. (2 pp.)

Before alloy steels, particularly in sheet form, were available to oven manufacturers, the maximum temperature at which an oven could be used was in the neighborhood of 700°-800°F. With the advent of alloy steels that could be fabricated with machinery normally used, temperatures up to approximately 1250°F are not uncommon. Author discusses broad applications possible.

Space Heating

Central Station Heating and Cooling. Hartford: First Gas Company in Central Heating—Cooling. W. T. Jebb. *Gas Age 127,* 25 (1961) Mar. 2 (3 pp.)

New concept in city redevelopment, the commercial Plaza, provides the gas utility with a new concept in service—central station cooling tied in with heating. In a three-part report covering the first approach in this direction by the Hartford Gas Company, three viewpoints are presented—utility, consulting engineer and manufacturer. In the first report, the president of Hartford Gas concludes that central station cooling added to heating affords the gas utility a giant-sized new market, and an opportunity to improve load balance to strengthen its bargaining position with gas suppliers.

Central Station Heating and Cooling. The Pros and Cons of Central Heating—Cooling. E. B. J. Roos. *Gas Age 127,* 28 (1961) Mar. 2 (3 pp.)

Second report, by a consulting engineer, points out that there is no rule of thumb for determining the value of a central station in a given condition. Biggest factor is external distribution, whose cost must be weighed carefully against the advantages offered by central operation.

Central Station Heating and Cooling. Potential: $100 Million a Year. R. Gray. *Gas Age 127,* 29 (1961) Mar. 2.

Manufacturer says that the Hartford development is not unique. On the contrary, it is only the forerunner of some 50 or more urban redevelopment plans and projects in 25 major cities. Projects compiled by author's company will probably represent an investment well in excess of $5 billion. If all of the space were to be air conditioned, it would require more than a half-million tons of refrigeration.

Gas Infra-Red Heating Cuts Costs by One-Third at Yoder Plant. *Ind. Gas (Amer.) 39,* 3 (1961) Feb. (2 pp.)

Gas-fired infrared heating system kept plant described at a constant 68°F last winter and used only two-thirds of the fuel estimated. Metal forming machinery maker uses 99 Perfection Schwank burners in building space totaling 1,581,000 cu. ft; heat loss for building is estimated to be 3,740,000 Btu/hr.

10. EQUIPMENT AND INSTRUMENTATION

Computers

Computer Dispatching Is Coming. R. E. Burrell. *Pipe Line Ind. 14,* 47 (1961) Feb. (3 pp.)

Several groups have conducted studies that indicate this step is practical. Developments in the past few years made remote measurements and telemetering readily available; now field computers can convert differential and static pressures, temperatures and other factors into flow.

Gas Turbines

The Small Gas Turbine—Today and Tomorrow. H. R. Schelp. *Gas Age 127,* 37 (1961) Mar. 2 (3 pp.)

Author presents the combination gas turbine and steam turbine cycle as the most efficient prime mover today. Natural advantages of the small gas turbine plus trends in design improvements are giving favorable indications as to eventual initial cost, fuel consumption, maintenance cost and overhaul cost. Author predicts the gas turbine will prove to be the most efficient unit over the long run, with a profound effect on the world economy.

Heat Exchangers

Ceramic Heat Exchangers for High-Temperature Heat Transfer from Helium. S. C. Browning and J. J. S. Sebastian. *Ind. Eng. Chem. 53,* 191 (1961) Mar. (6 pp.)

Research was undertaken to develop a ceramic heat exchanger to operate at high temperatures for utilizing nuclear heat from gas-cooled process heat reactors. The transfer of heat from helium flowing through a single-tube vitreous alumina heat exchanger was studied. Inside film coefficients were determined at mean surface temperatures of 200° to 1570°F, inlet gas temperatures of 1450° to 2665°F, and Reynolds numbers up to 560. The gas-to-surface temperature ratio was varied from 1.05 to 7.6. The Nusselt number for the lower

laminar region decreased as the ratio of gas-to-wall temperature was increased. This relationship is expressed by an equation involving dimensionless groups.

High Pressure

High-Pressure Measurement. D. H. Newhall and L. H. Abbott. *Instruments & Control Systems 34,* 232 (1961) Feb. (2 pp.)

New bulk-modulus-cell high-pressure gage provides ruggedness and reliability for the ranges between 0-50,000 and 0-200,000 psi. It comprises a hollow cylindrical steel probe, closed at its inner end. It is introduced into a thick-walled steel cylinder, the cell body, which is exposed to the high-pressure system. The probe is held in place by a threaded retainer which also serves to compress a conventional packing between shoulders on the cell body and probe. A stem projects one inch beyond the outer end of the probe proper. A clearance of 1/64 inch between the stem and the wall of the probe assures free stem motion.

Ultrahigh Pressure Research Today. J. E. Hilliard. *Ind. Eng. Chem.* 53, 42A (1961) Mar. (5 pp.)

Today materials are being manufactured commercially at a combination of high pressures and temperatures that a few years ago was unattainable, even in the laboratory. This is but one aspect of the rapidly growing application of high-pressure techniques which will assume increasing importance to the chemical process industry.

Instruments

Physical and Technical Principles of Some Types of Gas Measuring Instruments. G. Heinsohn. *Erdol u. Kohle 14,* 37 (1961) Jan. (3 pp. German text.)

After introductory remarks concerning the necessity of a permanent control of the industrial air for the presence of explosive and/or toxic gases and vapors in order to secure a maximum in industrial safety, a report is given about the physical principles and the technical design of some portable and permanently installed gas measuring instruments. Article deals especially with the principles of operation of the "Hot Wire" gas detection instrument, of instruments based on thermal conductivity, and a special electrochemical compensation measuring method. A second article will deal with the practical applications of the aforementioned equipment.

Pumps

Modern Development of Centrifugal Pumps. C. Bartolero and E. E. Lindros. (New York: ASME Paper No. 60-PET-42; 7 pp. $1.00/copy; $0.50 to members.)

In a paper presented to the ASME in June 1934, this statement was made: "In all probability today engineering improvements hydraulically have been brought to such perfection that, except on the boundaries of the centrifugal field, little more can be expected." Today, 26 years later, these boundaries have been so extended that few people close to the pump industry would now be willing to predict the limits, say authors. Paper discusses some of the problems presented to the pump industry and equipment developed for their solution.

11. MATERIALS OF CONSTRUCTION, AND CORROSION

Cathodic Protection

Impressed Current Anodes for Cathodic Protection. W. P. Noser. *Corrosion 16,* 587t (1960) Dec. (6 pp.)

Development and use of impressed current anodes for cathodic protection of underground structures is traced. Data for calculating anode resistance to earth are presented, and recommendations made for installing anodes for various soil conditions. Advantages are given for deep ground beds in high resistivity soil and in urban areas. Use of lead alloy and platinum anodes for underwater application is mentioned.

Lower, Less-Variable Power Needs Favor Deep Ground Beds. J. P. O'Donnell. *Oil Gas J. 59,* 117 (1961) Feb. 20 (3 pp.)

Deep ground beds, in a majority of cases, provide a more satisfactory method of cathodically protecting bare pipelines than conventional beds. This is the conviction of corrosion engineers with Interstate Oil Pipe Line Co. after more than three years' experience and thirty installations. This experience has led to some refinement and the standardization of techniques of installation. But, and most important, it has provided proof of the opening statement.

Material Study Relative to Corrosion. P. F. Marx. *Gas 37,* 83 (1961) Mar. (4 pp.)

Report covers certain results in the study of galvanic action of materials that might be used by one company to mitigate corrosion. Company's design purpose is to balance the cathodic effect of some materials against the relative areas of various parts, so that those materials having the smallest areas may be cathodically protected by parts having large areas subject to corrosion.

Coatings

Measurement of Coating Leakage Conductance. Part 1. M. E. Parker. *Pipeline Eng. 33,* D-20 (1961) Mar. (4 pp.)

Electrical conductance of pipe coating is a very useful quantity in the evaluation of its effectiveness. Alone, it is strongly indicative of coating quality, and is almost completely proportional to the amount of current required to maintain a line under cathodic protection. It fails to be directly indicative of coating quality because it is also influenced by soil resistivity; what is actually measured is not coating conductance alone, but leakage conductance to remote earth. This quantity can be measured for a bare line just as easily, and in fact by the same methods as are used for coated lines.

Painting of Welds. J. D. Keane and J. Bigos. *Corrosion 16,* 601t (1960) Dec. (7 pp.)

In an experimental study by the Steel Structures Painting Council, 1146 welded, treated and painted test specimens were exposed to determine methods of obtaining improved paint performance over the weld areas

of steel structures. During 30 months of exposure in an industrial atmosphere, the performance of primers and primer-topcoat systems was observed on various types of welds which had been given various surface preparations and pretreatments before being painted. It was found that residues caused by the electrode coating should be removed from the weld area. The method of paint application had no effect.

Sprayed Metal Coatings in the Gas Industry. R. E. Mansford. *Chem. & Ind.*, 150 (1961) Feb. 11 (11 pp.)

Sprayed metal coatings have been proved to be an effective protection against both the atmospheric corrosion and high-temperature oxidation encountered in the gas industry. They are not the cheapest form of protection and their indiscriminate use is not justified, but where long life is expected from the part to be protected a sound economic case for the use of metal spraying can be evolved. Some application schemes based on the possibilities of combining organic coatings and sprayed metal coatings are still in the early stages of development, and have not been evaluated.

Corrosion

Corrosion and the Gas Consumer. F. C. Moody and C. H. Purkis. *Chem. & Ind.*, 119 (1961) Feb. 4 (20 pp.)

In general, corrosion problems do not seriously affect the average gas consumer. Such problems as do arise are due to two main causes—corrosion by sulfur oxides in products of combustion and corrosion by water. The obvious solution to the sulfur corrosion problem is removal of the sulfur. Water corrosion problems are not peculiar to gas appliances but they can have widely felt consequences unless they are considered. Authors hope that this review of corrosion problems affecting the gas consumer will show to corrosion chemists and technologists the variety of problems arising in a predominantly domestic field.

High Temperature Corrosion in Refinery and Petrochemical Service. E. N. Skinner, J. F. Mason and J. J. Moran. *Corrosion 16,* 593t (1960) Dec. (8 pp.)

Paper is concerned with the corrosion phenomena likely to influence the selection of materials for refinery service at elevated temperatures. The problems of oxidation, sulfidation and carburization are discussed in detail and consideration is given to the effects of condensate corrosion and residual oil ash corrosion. The contributions of various alloying elements in the common engineering alloys to their physical and mechanical behavior as well as to their corrosion resistance at elevated temperatures are discussed. Basic considerations for the selection of suitable alloys to withstand high temperature corrosive environments are outlined.

Internal Carburization and Oxidation of Nickel-Chromium Alloys in Carbon Monoxide Type Atmospheres. B. E. Hopkinson and H. R. Copson. *Corrosion 16,* 608t (1960) Dec. (5 pp.)

Tests showed that the rate of internal carburization and oxidation of nickel-chromium alloys attains a maximum at 1500°-1750°F. Attack was slight at 1330° and 1830°F. The presence of carbon dioxide, water vapor and hydrogen in the carbon monoxide did not significantly affect the rate of penetration. Modified Inconel-type alloys resisted carburization and oxidation in all the atmospheres tested. The mechanisms involved are discussed.

Plastics

Corrosion-Resistant Hose: Where Does Teflon Fit In? E. M. Ramberg. *Chem. Eng. 68,* 180 (1961) Feb. 20 (4 pp.)

Until fairly recently, when some flexible hose had to be engineered into a process design, choice was limited to two materials: rubber or metal hose. Now, another material Teflon, has joined this group. While the material is no cure-all, Teflon-lined hose can solve many unusual and difficult fluid-handling problems.

What You Should Know about Thermoplastic Piping Systems. *Heating, Piping & Air Conditioning 33,* 127 (1961) Mar. (12 pp.)

Thermoplastics have rapidly gained acceptance as important construction materials for piping systems in many process industries. High chemical resistance has been responsible for their increasing usage. Low strength and limited heat resistance, as compared to metals, limits the application of thermoplastics. However, a working knowledge of these properties and their effect on design permit utilization of the favorable chemical resistance in a majority of piping applications. Report discusses properties of commonly used thermoplastic materials—including those for two newcomers—together with pointers on how to utilize them in design and installation.

12. ANALYTICAL METHODS AND TESTS

Chromatography

Adsorption on the Liquid Phase in Gas Chromatography. R. L. Martin. *Anal. Chem. 33,* 347 (1961) Mar. (6 pp.)

New equation in gas chromatography for retention volumes takes into account the contribution of adsorption at the liquid-gas interface. Liquid phase adsorption is critical when the liquid is highly polar and the surface area of the support is high. When nonpolar liquid phase is used, adsorption on the support is a factor.

Determination of Nitrogen with Gas Chromatography. R. H. Reitsema and N. L. Allphin. *Anal. Chem. 33,* 355 (1961) Mar. (5 pp.)

Two procedures are developed for nitrogen analyses: one gives a carbon to nitrogen ratio value and the other an absolute nitrogen value. The procedures combine combustion techniques with gas-liquid chromatography. Pure compounds and components of a mixture are determined by the procedures.

Diffusional Band Spreading in Gas-Chromatographic Columns. Part I. The Elution of Unsorbed Gases. J. Bohemen and J. H. Purnell. *J. Chem. Soc.* (1961) Jan. (8 pp.)

It has been shown that diffusion coefficients can be measured reasonably accurately from elution curves, and that the labyrinth constant for packed columns, γ, is probably unity. The eddy diffusion contribution to the plate height cannot be measured reliably, but probably lies between one and two support-particle diameters.

Gas Chromatography. G. M. Brown and J. Satsmadjis. *Coke and Gas 23,* (1961) Feb. (7 pp.)

Paper describes the development and use of a simple gas-solid chromatograph, and its application to routine gas analysis in town gas manufacture. Carbon dioxide is used as carrier gas, and the eluted component gases are measured volumetrically by a new technique after absorption of the carbon dioxide in potash. The analysis includes the permanent gases with the exception of CO_2 and O_2 (although the sum $N_2 + O_2$ is given) and saturated and unsaturated hydrocarbons up to and including C_4. The analyzer requires no services.

Now Use Gas Chromatography for Glycol Analysis. D. F. Wisniewski and G. C. Stalker. *Petrol. Refiner 40,* 117 (1961) Feb. (4 pp.)

Four glycols of ethylene can be defined in solution singly or in mixture with good precision using the method proposed here. Suggestions are given for making chromatographic apparatus. Glycol solutions can be analyzed more accurately and in less time by gas chromatography than by many of the more conventional methods. This technique is useful not only for routine quality control but also for special trouble shooting situations, and the equipment needed is easily constructed, inexpensive, simple to use.

Gas-Liquid Chromatographic Analysis of Trace Impurities in Styrene Using Capillary Columns. O. L. Hollis. *Anal. Chem. 33,* 352 (1961) Mar. (4 pp.)

Procedure combining gas-liquid chromatography using capillary columns with a triode argon detector is applied for the separation and detection of trace impurities in styrene. Various xylenes and other impurities are separated and detected at concentrations below 25 ppm without the need of a concentration step.

Quantitative Analysis for Carbonyl Sulfide in Natural Gas by Gas-Liquid Chromatography. J. A. Schols. *Anal. Chem. 33,* 359 (1961) Mar. (2 pp.)

Gas-liquid method using *N,N*-di-*n*-butylacetamide as a stationary phase determines from 25 to 1000 ppm carbonyl sulfide in natural gas. Sensitivity is obtained by using a thermistor-type thermal conductivity detector cell. One analysis is completed within six minutes.

Density

Radioactive Measurement of Fluid Density. D. G. Hartweg. (New York: ASME Paper No. 60-PET-48; 8 pp. $1.00/copy; $0.50 to members.)

Method is described for measuring densities of cement, mud, sand slurries or inhibited hydrochloric-acid solutions, using radioisotopes and suitable, calibrated detection gages.

Mass Spectrometry

Total Analysis of Olefinic Naphthas by Mass Spectrometry. A. J. Frisque, H. M. Grubb, C. H. Ehrhardt and R. W. Vander Haar. *Anal. Chem. 33,* 389 (1961) Mar. (3 pp.)

New mass spectra method is developed that combines low and normal voltage spectra so that the strong features of each offset the weak feature of the other. The new procedure is applied to the determination of hydrocarbon types of olefinic naphthas. The mass spectrometer is modified to provide the low ionizing and fixed repeller voltages required.

Moisture

A Thermodynamic Approach to the Measurement of Hygroscopicity. Aqueous Vapor Pressure of Univariant, Binary Systems, and Hygroscopicity Potential. M. M. Markowitz and D. A. Boryta. *J. Chem. Eng. Data 6,* 16 (1961) Jan. (3 pp.)

Measurements of the aqueous vapor pressure of a univariant salt-water system provide the fundamental thermodynamic data to determine whether a material, given sufficient time, will be hygroscopic at a particular p_{H_2O}, sys./p_{H_2O}, atm. ratio. For values of the ratio less than one, the rate at which atmospheric water is absorbed is dependent on many factors. The individual effects of these variables are usually unresolved in the customary kinetic experiment. As a consequence, the kinetic results are very sensitive to the physical circumstances of the material and cannot be extrapolated reliably to other experimental conditions.

Sampling

Successful Sampling. P. H. Stirling and H. Ho. *Ind. Eng. Chem. 53,* 57A (1961) Mar. (4 pp.)

High returns and rapid pay-offs show that the precautions needed for reliable operation of analyzers are worthwhile. Analyzer should not be separated from its sampling system. Automatic analyzers used for monitoring or automatic control are often the final arbiters of quality and economic gain. These demanding applications require rapid response, accuracy, and the utmost in reliability.

Surface Area

A Method of Measuring the Surface Area of Granular Material. C. P. Hedlin and S. H. Collins. *Can. J. Chem. 39,* 49 (1961) Feb. (3 pp.)

Method is described which permits measurements of the exterior surface areas of objects down to about 0.1 sq in. Systematic variations in the density of the metal particle coating are discussed, and appropriate correction factors are given. Method is intended for use in research that involves objects whose exterior surface areas have an effect on the process being investigated.

13. BASIC SCIENCE

Diffusion

Kirkendall Effect in Gaseous Diffusion. K. P. McCarty and E. A. Mason. *Phys. Fluids 3,* 908 (1960) Nov.-Dec. (15 pp.)

Experiment is described which is the analog of the well-known Kirkendall effect in solids. The experiment can also be thought of as a measurement of the pressure differences arising in a diffusing gas mixture. Seven gas mixtures were measured at 30°C and over a maximum pressure range of about 0.2 to 1.7 atm as follows: H_2-D_2, CO_2-C_2H_8, He-Ar, He-CO_2, H_2-CO_2, D_2-CO_2 and H_2-(H_2 + CO_2 mixture). The results are discussed in terms of the usual phenomenological theory of the Kirkendall effect and the rigorous kinetic theory of gases.

Fluid Flow

Fluid Mechanics (Course of Theoretical Physics, Vol. 6). L. D. Landau and E. M. Lifshitz; trans. from Russian by J. B. Sykes and W. H. Reid. (Reading, Mass.: Addison-Wesley Publishing Co., Inc., 1959, xii + 536 pp. $14.50). [From *Appl. Mech. Rev. 14,* 127 (1961) Feb.]

Scope of the work can be appreciated from the chapter headings: ideal fluids; viscous fluids; turbulence; boundary layers; thermal conduction in fluids; diffusion; surface phenomena; sound; shock waves; one-dimensional gas flow; intersection of surfaces of discontinuity; two-dimensional gas flow; flow past finite bodies; fluid dynamics of combustion; relativistic fluid dynamics; dynamics of superfluids; fluctuations in fluid dynamics.

L. J. F. Broer, Holland

On the Statistical Dynamics of an Incompressible Turbulent Fluid. B. I. Davydov. *Soviet Phys.-Doklady 4,* 769 (1960) Feb. (4 pp.) Translation of *Dokladi Akad. Nauk SSSR (N.S.) 127,* 768 (1959) July/Aug. (4 pp.) by Amer. Inst. Phys. Inc., New York, N. Y. [From *Appl. Mech. Rev. 14,* 129 (1961) Feb.]

Turbulent flow bounded by solid walls is treated in the manner of Kolmogorov whereby an ensemble of flows is considered, each of which is independent of the others but subject to the same constraints. The flow of the fluid is then described by a probability distribution of the various hydrodynamic quantities and their corresponding moments determined from the ensemble. The fundamental flow quantities chosen were the mean velocity and mean pressure, the second and third moments of fluctuating velocities, and the turbulent energy dissipation.

R. M. Drake, Jr., USA

On the Statistical Theory of Turbulence. B. I. Davydov. *Soviet Phys. Doklady 4,* 779 (1960) Feb. (3 pp.) Translation of *Dokladi Akad. Nauk SSSR (N.S.) 127,* 980 (1959) July/Aug. (3 pp.) by Amer. Inst. Phys., Inc., New York, N. Y. [From *Appl. Mech. Rev. 14,* 129 (1961) Feb.]

Consideration of the equation developed in preceding paper as applied to turbulent flow with logarithmic velocity distribution. Experimental results of Laufer for turbulent pipe flow were used to determine the arising empirical constant. Final results are shown in terms of only two empirical dimensionless constants.

R. M. Dake, Jr., USA

The Orifice Flow Section for Metering Low Rates of Flow. T. J. Filban. *Instruments & Control Systems 34,* 296 (1961) Feb. (2 pp.)

Article discusses one company's program to establish a small flow laboratory to investigate the possibility of applying known orifice meter practices, applicable to larger sizes, to a miniature counterpart with a view toward determining if there was a possibility of designing a unit whose performance could be predictable.

Theory of Gas Bubble Dynamics in Oscillating Pressure Fields. M. S. Plesset and D. Y. Hsieh. *Phys. Fluids 3,* 883 (1960) Nov.-Dec. (11 pp.)

Behavior of a permanent gas bubble in a liquid with an oscillating pressure field is analyzed with a linearized theory. If the assumption is made that conditions within the bubble are uniform, the thermodynamic relations found are as expected; i.e., at low frequencies the bubble behaves iso-thermally and at high frequencies the behavior becomes adiabatic. However, a more detailed analysis which allows the bubble interior to vary not only in time but also in space, leads to an average isothermal behavior for the bubble even in the high-frequency limit.

Heat Transfer

Heat Emission from the Wall to the Gases in Tubes with Fittings of Complex Parameters. Y. F. Batishshev. *Trudi Novovherk. Politekhn. In-ta,* 45 (70/84) 1957 (19 pp. Russian text.); *Ref. Zh. Mekh.,* No. 3, 1959, Rev. 2704. [From *Appl. Mech. Rev. 14,* 145 (1961) Feb.]

Relation is recommended for calculating the heat emission from the walls to the various gases in a tube with a fitting of arbitrary geometrical form, made of materials with different heat conductivities and roughness. This was obtained as the result of experiments by the author for the case of heat emission to the air in a tube fitted with smooth steel balls. Data of other investigators are used to justify the calculations.

E. A. Nakhapetyan
Courtesy Referativnyi Zhurnal, USSR

Influence Coefficients for Radiation in a Circular Cylinder. E. W. Parkes. AFOSR TN-60-415 (Stanford Univ., Dept. Aero. Eng. No. 92). (1960) Mar. (11 pp.) [From *Appl. Mech. Rev. 14,* 145 (1961) Feb.]

Radiation with absorption and reflection on the interior surface of an infinite circular cylinder is treated. The basic problem considered is the determination of the intensity of radiation absorption as a function of angular position on the surface when there is an initial emission of radiation that is distributed arbitrarily with respect to angular position.

J. E. Plapp, USA

Heat Transfer by Natural Convection in Fluids in Critical Condition. E. Schmidt. *Inter. J. Heat and Mass Transfer 1*, 92 (1960) June (10 pp. German text.) [From *Appl. Mech. Rev. 14*, 144 (1961) Feb. (2 pp.)]

Experiments on natural convection of ammonia and of carbon dioxide in vertical tubes heated near the bottom and cooled near the top show that at a given rate of heat transfer, an extremely low temperature gradient is obtained near the critical point of the fluid. The axial transmission of heat by natural convection was represented by an effective thermal conductivity; a maximum value of 14 kw/cm°C was found for the central part of the largest tube. The experimental data are explained by the increases in the specific heat and in the coefficient of thermal expansion up to infinity at the critical point.

H. A. Vreedenberg, Holland

Simultaneous Heat and Mass Transfer. Part 2. F. Molyneux. *Chem. & Process Eng. 42*, 65 (1961) Feb. (5 pp.)

One of the problems associated with the storage and transport of liquid gases is the reduction of losses from tanks containing these gases at lower temperatures. Author describes a design for a vent condenser, supplied with refrigerant as a coolant and capable of reducing the liquid gas breather losses by 75 percent. Such a plant provides one means of reducing these losses: utilizing standard longitudinal fin double-pipe heat exchanger, produced as units by many manufacturers.

The Heat-Balance Integral—Further Considerations and Refinements. T. R. Goodman. *J. Heat Transfer 83*, 83 (1961) Feb. (4 pp.)

Integral methods have previously been applied to transient heat conduction in a slab with constant thermal properties. In this paper the method is extended so as to include temperature-dependent thermal properties in the analysis. In addition, it is shown how to improve the accuracy of a solution by increasing the order of the polynomial used to represent the temperature profile. For the case of a prescribed step surface temperature in a semi-infinite slab, a quartic profile is shown to give excellent accuracy.

Hydrocarbons

Enthalpy of Petroleum Fractions. R. L. Johnson and H. G. Grayson. *Petrol-Refiner 40*, 123 (1961) Feb. (7 pp.)

Convenient charts are available to determine the enthalpy of petroleum fractions as a function of temperature, density, composition and pressure. The basic data are unchanged from earlier publications. However, pressure corrections for the enthalpy of petroleum fraction vapors have been revised based on the Hydersen, Greenkorn and Hougen correlation. The incorporation of pseudo-critical properties and phase relationships in four basic charts promotes clarity and ease of use while reducing potential errors inherent in earlier methods of presentation.

Heats of Combustion, Isomerization, and Formation of Selected C_7, C_8 and C_{10} Monoolefin Hydrocarbons, J. D. Rockenfeller and F. D. Rossini. *J. Phys. Chem. 65*, 267 (1961) Feb. (6 pp.)

Measurements were made of the heats of combustion, in the liquid state at 25°C, of 19 selected monoolefin hydrocarbons, including 10 heptenes, 6 octenes and 3 decenes. From these and appropriate other data were calculated values of standard heats of isomerization, formation and hydrogenation, as appropriate, for the liquid state at 25°C. For most of the compounds, values are also given for the gaseous state. The relation between energy content and molecular structure for these compounds is discussed.

Methane

The Mercury-Sensitized Radiolysis and Photolysis of Methane. G. J. Mains and A. S. Newton, *J. Phys. Chem. 65*, 212 (1961) Feb. (6 pp.)

Radiation chemistry of methane at 260°C using 4.5 Mev. electrons was studied in the absence and presence of mercury vapor. The mercury-sensitized photolysis of methane at 260°C and the radiolysis of methane at 25°C were studied for comparison. The condensation products were analyzed by mass spectrometry and the yields of H_2, C_2H_4, C_2H_6, C_3H_8, iso-C_4H_{10}, *n*-C_4H_{10}, iso-C_5H_{12}, neo-C_5H_{12} and neo-C_6H_{14} are reported in each case. The failure of mercury vapor to alter the product distribution by ion scavenging is taken as evidence for little contribution of ion-molecule reactions in methane radiolysis at 260°C. A mechanism involving both ion-radicals and radicals is consistent with the data.

The Vapor Pressure, Heat of Vaporization and Heat Capacity of Methane From the Boiling Point to the Critical Temperature. P. Hestermans and D. White. *J. Phys. Chem. 65*, 362 (1961) Feb. (4 pp.)

Vapor pressures, heats of vaporization and heat capacities of methane from the boiling point to the critical temperature have been measured. The vapor pressure data have been represented in the form log $P_{atm} = 3.984667 - 444.6667/T - \delta(T)$, where $\delta(T)$ is tabulated at equal intervals of temperature. The normal boiling point of methane is 111.42°K. Critical constants have been calculated from the vapor pressure data. It is shown that the measured heats of vaporization are in good agreement with those calculated from the above vapor pressure equation and the known liquid and gaseous densities. The heat capacity data, when combined with the measured heats of vaporization, yield entropies for the gas along the saturation curve in excellent agreement with those obtained from statistical calculations.

Phase Equilibria

Experimental Determination of Limit of Supersaturation of Nitrogen Vapor Expanding in a Nozzle. G. L. Goglia and G. J. van Wylen. *J. Heat Transfer 83*, 27 (1961) Feb. (6 pp.)

Limit line of supersaturation of slightly superheated nitrogen vapor as it expands in a two-dimensional

nozzle has been determined. The results indicate that the degrees of supersaturation vary from 12.3°F at a condensation temperature of 109°R, to 3.5°F at 126°R. These results are in agreement with work of other investigations with nitrogen gas initially at room temperature.

Phase Equilibria in Natural Gas Systems. Data for Two Helium-Bearing Natural Gases. L. W. Brandt, L. Stroud, and J. E. Miller. *J. Chem. Eng. Data 6,* 6 (1961) Jan. (8 pp.)

Purpose of investigation was to obtain analysis of equilibrium liquid and vapor phases at pressures from 100-500 psia, and temperatures ranging from −100° to −250°F for both the gas serving as feed to the government's Amarillo (Texas) plant and for a "helium-conservation" gas which was of interest as a representative helium source in the conservation program. Article contains previously unavailable information on phase equilibria of helium-bearing natural gases.

Shock Tubes

Periodic Shock Waves in Resonating Gas Columns. R. A. Saenger and G. E. Hudson. *J. Acoust. Soc. 32,* 961 (1960) Aug. (10 pp.) [From *Appl. Mech. Rev. 14,* 126 (1961) Feb.)]

Theory of the steady-state motion of the gas in its "fundamental" mode has been devised which includes the dissipative effects of wall friction and heat conduction to the tube walls. The dependence of shock strength, mean temperature, and mean pressure on piston amplitude, tube length, gas viscosity, and heat conductivity predicted by the theory are in good qualitative agreement with the small number of experimental data available.

From authors' summary

Solubility

Solubility and Entropy of Solution of He, N_2, A, O_2, CH_4, C_2H_6, CO_2 and SF_6 in Various Solvents; Regularity of Gas Solubilities. Y. Kobatake and J. H. Hildebrand. *J. Phys. Chem. 65,* 331 (1961) Feb. (5 pp.)

Careful measurements of gas solubility in selected solvents have been made in the range 5-30°C. The apparatus and procedure are described in some detail. The gas, solvent, mole fraction x 10^4 at 1 atmosphere and 25°C, and the entropy of solution, cal. $mole^{-1}$ $deg.^{-1}$, respectively, are given. Figures are plotted as 1) entropy of solution vs $-R \ln x_2$; 2) $\log x_2$ vs solubility parameters of solvents; 3) $\log x_2$ vs force constants of gases. They show extensive regularities with high predictive value and theoretical significance.

Thermal Conductivity

Thermal Conductivity and Eucken-Type Factor for the Binary Mixtures H-He H-Ne K-Kr and H-Xe. A. K. Barua. *Indian J. Phys. 34,* 169 (1960) Apr. (15 pp.) [From *Appl. Mech. Rev. 14,* 139 (1961) Feb.]

In order to test the recent formulas for the thermal conductivity of polyatomic gas mixtures, the thermal conductivity of H_2-He, H_2-Ne, H_2-Kr and H_2-Xe mixtures have been measured at 30° and 45°C by using the thick-wire-variant of the hot-wire method. The experimental values of the thermal conductivity of the pure gases and their binary mixtures is lower than those given by Hirschfelder's theory based on the local chemical equilibrium assumption. It has been suggested that this discrepancy between theory and experiments at the temperatures under consideration is due to the nonvalidity of the condition of local chemical equilibrium.

From author's summary

Thermodynamics

Thermodynamic Data for the Calculation of Gas Turbine Performance. D. Fielding and J. E. C. Topps. Aero. Res. Council London, Rep. Mem. 3099, 115 pp., 1959. [From *Appl. Mech. Rev. 14,* 149 (1961) Feb.]

Enthalpy, entropy, and specific heat at constant pressure are tabluated for dry air at 1°K intervals from 200° to 2000°K. To achieve accuracy of 1.0 percent in specific fuel consumption without onerous computations, the method of using the difference between the property of a gas mixture and the same property for air is used. Use of equations for the method is discussed. The properties of any mixture of C, H, O, N and S in the temperature range 200° to 2000°K can be computed using the tables.

A. Fuhs, USA

Viscosity

Viscosity of Two Component Gaseous Mixtures. J. O. Hirschfelder, M. H. Taylor and T. Kihara. Univ. Wisconsin, Theoretical Chem. Lab., WIS-OOR-29, Series 2 & 5, 16 pp., July 1960. [From *Appl. Mech. Rev. 14,* 139 (1961) Feb.]

Conditions are found where the viscosity of a binary mixture of dilute gases either has a maximum or a minimum with respect to variations in the composition. There are many experimental examples of maxima in the viscosity, but up to the present time, no cases have been discovered where the viscosity has a minimum. The maximum value of the viscosity and the mole fraction at which it occurs can be used to determine the energy of interaction between unlike molecules.

From authors' summary

Water

Heavy-Water Plant Molds New Features. N. P. Chopey. *Chem. Eng. 68,* 118 (1961) Feb. 20 (4 pp.)

European technology has come up with yet another route for extracting heavy from natural water—a direct, simple one boasting a variety of process features. Developed by Sulzer Bros., Ltd., Winterthur, Switzerland, it is currently in use at a small plant operated by Emser Werke AG at Domat-Ems, Switzerland, which supplies its output to both local and French nuclear agencies. Process follows a three-step path in extracting heavy water.

Services Available to GAS ABSTRACTS Readers

Photocopies

Photocopies of all articles abstracted in *Gas Abstracts*, except those enumerated here, are available from the Institute at cost:*

1) Russian Articles.—Abstracts are obtained from services specializing in this field. English translations can be supplied by arrangement with the appropriate abstractor.
2) U.S. Patents.—Printed copies can be secured at 25 cents each (remittance with order) from the Commissioner of Patents, Washington 25, D.C.
3) Books, Special Reports.—When a price is given in the abstract, these should be secured from a bookdealer or the publisher; when stated *free*, from the publisher.

Types of Photocopies

Depending on the "tightness" of the binding (which determines whether pages can be laid flat without breaking the binding), and the color of the paper and ink used in the original being copied, photocopies may take any of several forms:

1. Positive paper prints made by the reflex process.
2. Positive paper prints enlarged by xerography from microfilm negatives.
3. Negative photostats.
4. Positive photostats.

Choice of the method used must necessarily rest with the Institute. All photocopies are approximately the same size as the original material.

Cost of Service

The photocopy service charge is:

First 5 pages or fraction thereof of one article in one issue $1.50

Each subsequent 4 pages or fraction thereof of the above one article in the same issue.....$1.00

Invoices are rendered to the Institute's Members and Contributors only; payment in advance is required of others.

The Institute may, at its option, fill orders from non-Members and non-Contributors without payment in advance, but an additional charge of $1.00 to cover billing costs will be made on each such order.

Microfilm

Microfilm copies of articles abstracted in *Gas Abstracts* are likewise available at cost.* The material is photographed on 35 mm unperforated negative film at 5¢ per page, with a minimum of 50 pages, $2.50, per order. Invoices are rendered to the Institute's Members and Contributors only; payment in advance is required of others.

The Institute may, at its option, fill orders from non-Members and non-Contributors without payment in advance, but an additional charge of $1.00 to cover billing costs will be made on each such order.

Bibliographies and Literature Searches

The library will prepare bibliographies and make literature searches on a cost basis plus a service charge. A comprehensive statement detailing the problem must be presented with the request.

Gas Abstracts on Cards

The abstracts in each monthly issue are also printed individually on 5 x 8-inch cards. Each card bears at its top the author and subject headings under which it may be filed. As many copies of each card are supplied as there are headings on that card, enabling filing of the abstract under all of its headings, eliminating cross-indexing.

The annual subscription to *Gas Abstracts on Cards*, a mailing of 500-1000 cards each month, is $120.00 to U. S. addresses, $150.00 foreign.

Since the printing order for cards is based on the current number of subscribers, a subscription for this service commences with the month in which the order is received. Back numbers of *Gas Abstracts on Cards* are not available.

Back Numbers of Gas Abstracts

In response to an increasing number of requests from utilities, colleges, and technical libraries which have only recently learned of the reference value of *Gas Abstracts*, the Institute has taken steps to make available single numbers, volumes, or complete files of this publication to date, starting with Vols. 1 (1945) and 2 (1946), some numbers of which are out of print.

The latter numbers are reproduced by a photoprinting process from copies in the Institute's libraries, and Vols. 1 and 2 can now be purchased at $35 per volume, unbound; single monthly numbers are offered at $3 each.

Vols. 3 to date are available at current subscription prices, $18 per volume to U. S. addresses, $22 foreign. Monthly numbers are $2 each.

---

*In requesting and accepting photocopies or microfilm copies, the applicant agrees to the following:

1. The applicant desires this duplication solely for use in lieu of loan or manual transcription. Responsibility for questions of copyright that might arise in this copying, and in the use of the copies, is assumed by the applicant.

2. The applicant understands that the Institute does not sell the photocopies, but merely performs the service of copying at the applicant's request; the fee paid is exclusively for such service and is established on the basis of no profit to the Institute.

3. The Institute reserves the right at its own discretion to decline to make photocopies requested, or to limit the number of copies, within the principle of fair use of copyrighted material.

Publications Abstracted for GAS ABSTRACTS

Air Conditioning, Heating and Ventilating
Air Engineering
Air Pollution Control Association, Journal of
American Chemical Society, Journal of
American Gas Association Monthly
American Gas Journal
American Institute of Chemical Engineers, Journal of
American Society of Mechanical Engineers, Transactions of
Engineering for Power, Journal of (Series A)
Engineering for Industry, Journal of (Series B)
Heat Transfer, Journal of (Series C)
Basic Engineering, Journal of (Series D)
Applied Mechanics, Journal of (Series E)
Analytical Chemistry
Appliance Manufacturer
Applied Chemistry, Journal of
Applied Mechanics Reviews
Applied Physics, Journal of
Applied Spectroscopy
ARS Journal
ASHRAE J.
Australian Journal of Applied Science
Australian Journal of Chemistry
Battelle Technical Review
Bituminous Coal Research
Brennstoff-Chemie (German)
British Coal Utilization Research Association Monthly Bulletin and Quarterly Gazette
Business Week
Butane-Propane News
California Oil World
Canadian Chemical Processing
Canadian Gas Journal
Canadian Journal of Chemical Engineering
Canadian Journal of Chemistry
Canadian Journal of Physics
Ceramics (British)
Chemical and Engineering Data, Journal of
Chemical and Engineering News
Chemical & Process Engineering
Chemical Documentation, Journal of
Chemical Education, Journal of
Chemical Engineering
Chemical Engineering Progress
Chemical Physics, Journal of
Chemical Processing
Chemical Reviews
Chemical Society, Journal of (British)
Chemical Society, Proceedings (British)
Chemical Week
Chemistry & Industry (British)
Coal-Heat
Coal Utilization
Coke and Gas (British)
College Placement, Journal of
Combustion
Combustion and Flame (British)
Communications of the ACM
Compressed Air
Computers and Automation
Construction Methods and Equipment
Control Engineering
Corrosion
Corrosion Technology (British)
Cost Engineering
Datamation
Design News
Drilling
Electronics
Engineers' Digest (British)
Erdöl und Kohle (German)
Faraday Society, Transactions of (British)
Fuel (British)
Fuel Efficiency (British)
Fueloil & Oil Heat
Gas
Gas Age
Gas & Oil Power (British)
Gas Council Research Communications (British)
Gas Heat and Comfort Cooling
Gas Industries
Gas Journal (British)
Gas Service and Domestic Coke
Gas Times (British)
Gas- und Wasserfach (German)
Gas World (British)
Gazovaya Promyshlennost (Russian)
Heating, Piping & Air Conditioning
Independent Petroleum Association of America Monthly
Industrial and Engineering Chemistry
Industrial Finishing (British)
Industrial Gas (American)
Industrial Gas (British)
Industrial Heating
Industrial Research
Industries du Gaz, Journal des (French)
Institute of Fuel, Journal of (British)
Institute of Gas Technology Research Bulletins
Institute of Petroleum, Journal of (British)
Institution of Gas Engineers Bulletins and Communications (British)
Instrumentation
Instruments and Control Systems
Izvestiva Akademii Nauk S. S. S. R. Otdelenie Khimicheskikh Nauk (Russian)
Khimiya i Tekhnologiya Topliva i Masel (Russian)
LP-Gas
Lubrication
Lubrication Engineer
Materials Research & Standards
Mathematical Aids to Computation
Mechanical Engineering
Metals, Journal of
National Aeronautics and Space Administration Memorandum
National Fire Protection Association Quarterly
National Gas Bulletin of Australia
National Petroleum News
Nuclear Science and Engineering
Nucleonics
Oil and Gas Journal
Optical Society of America, Journal of
Organic Chemistry, Journal of
Petro/Chem Engineer
Petroleum (British)
Petroleum Engineer, The (Drilling and Producing)
Petroleum Engineer, The (for Management)
Petroleum Refiner
Petroleum Technology Journal of
Petroleum Times
Petroleum Week
Physical Chemistry, Journal of
Physics and Chemistry of Solids (British)
Physics of Fluids (British)
Physics Today
Pipeline Engineer
Pipe Line Industry
Pipeline News
Power
Producers Monthly
Product Engineering
Progress (Pakistan)
Public Utilities Fortnightly
Research/Development
Research, Journal of, A. Physics and Chemistry
Research, Journal of, B. Mathematics and Mathematical Physics
Research, Journal of, C. Engineering and Instrumentation
Review of Scientific Instruments
Revue Generale du Gaz (Belgian)
Rivista dei Combustibili (Italian)
Science
Scientific & Industrial Research, Journal of, A. General (India)
Scientific & Industrial Research, Journal of, B. Physical Sciences (India)
Scientific Instruments, Journal of (British)
Solid-State Electronics
Stroitel'stvo Truboprovodov (Russian)
Svenska Gasverksföreningens Månadsblad (Swedish)
Technical News Bulletin
U.S. Bureau of Mines Bulletins, Information Circulars and Reports of Investigations
U.S. Patents
Uspekhi Khimii (Russian)
World Oil
World Petroleum